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Research Product 82-6

**Intelligence Aid for Evaluating
Enemy Courses of Action (ENCOA):**

**Guide for Manual and
HP41-C/HP41-CV Calculator Procedures**

Human Factors Technical Area

June 1982

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A Field Operating Agency under the Jurisdiction of the
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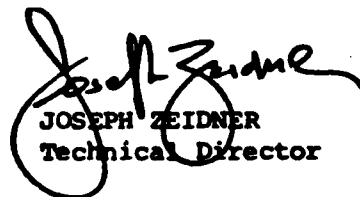
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instruction. Use of these procedures is expected to enhance the analyst's assessment of the enemy situation as well as the communication and mutual understanding between intelligence analysts and their commander. A computerized version of these procedures is described in ARI Research Product 83-10.

FOREWORD

The Human Factors Technical Area is concerned with the demands of the future battlefields for increased user/system capacity to acquire, transmit, process, disseminate, and utilize information. Research is focused on user/system interface problems and interactions within command, control, and intelligence centers and is concerned with areas such as tactical symbology, user-oriented systems, information processing and management, and staff operations and procedures, as well as sensor systems integration and utilization.

One area of special interest is the development of procedures to support and enhance the decision-making process within command, control, and intelligence centers. The current research product is a manual describing a set of procedures for evaluating enemy courses of action. Based on well-documented, decision-theoretic techniques, these procedures will encourage intelligence analysts to organize and evaluate available information logically and systematically in formulating their assessment and prediction of enemy intentions/activities/events. Use of these procedures is expected to enhance not only the analyst's assessment of the enemy situation, but also the communication and mutual understanding between intelligence analysts and their commander. This guide describes procedures that are conducted manually or with the HP41-C/HP41-CV calculator. A computerized version of these procedures is described in ARI Research Product 83-10.



JOSEPH ZEIDNER
Technical Director

EXECUTIVE SUMMARY

Requirement:

To develop for intelligence analysts a set of procedures that will encourage logical and systematic organization of available information as well as support and enhance the decision-making process in the tactical evaluation of enemy intentions/activities/events.

Procedure:

The intelligence aid is based on a combined study of the intelligence process and decision-theoretic techniques. Using the well-documented technique of multiattribute utility assessment, the overall problem of assessing the relative likelihood of enemy courses of action is broken down into a series of steps. The steps require an analyst to evaluate possible enemy courses of action on 25 component factors organized in five mutually exclusive categories. These component evaluations are then aggregated to produce an assessment of the overall relative likelihood for each alternative course of action.

Findings:

General procedures to evaluate and predict enemy activities have been developed within the Army's doctrine of Intelligence Preparation of the Battlefield (IPB). However, these procedures do not provide an explicit description of how to conduct actual analyses. This intelligence aid has been developed to supplement IPB procedures.

Utilization of Findings:

The manual contains complete background rationale for the aid, instructions for calculation of the aid by hand or with a Hewlett-Packard HP41-C or HP41-CV calculator, worksheets, and a sample problem. It is intended for use by intelligence analysts in field operations, tactical training, and academic instruction. The aid is designed to assist the analyst in organizing relevant information concerning terrain, weather, and enemy forces and to provide a logical structure for utilizing this information to evaluate the likelihood of alternative enemy courses of action. It is expected to enhance the analyst's assessment of the enemy situation as well as the communication and mutual understanding between intelligence analysts and their commander.

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INTRODUCTION

The ENCOA (Enemy Course of Action) aid described in this manual is intended for use in the tactical evaluation of opposing forces (see Figure 1 for an overview). The aid is designed to assist the intelligence analyst in organizing the relevant information concerning terrain, weather, and opposing forces (size, disposition, capabilities, etc.) and to provide a logical structure for utilizing this information in evaluating the likelihood of alternative enemy courses of action in any given tactical situation.

Army doctrine provides discussions of the factors to be used in identifying the most likely enemy course of action (FM 30-5, Combat Intelligence). General procedures using templating techniques to evaluate and predict enemy activities have been developed by the Army within the doctrine of Intelligence Preparation of the Battlefield (IPB). However, these procedures are not sufficiently explicit about how to conduct the actual analyses and predictions of enemy courses of action. The ENCOA intelligence aid has been developed specifically to supplement the procedures of FM 30-5 and IPB.

Intelligence Preparation of the Battlefield, TC 30-27, was prepared by the U.S. Army Intelligence Center and School as guidance to commanders, staff officers, and military intelligence personnel in G2/S2 sections or assigned to military intelligence organizations at all echelons. It standardizes basic tactical intelligence analytical functions, procedures, and techniques and identifies essential information for opposing forces (OPFOR), weather, and terrain. The techniques described are applicable to both offensive and defensive operations, focusing on the integration and analysis of OPFOR doctrine, terrain, and weather information relative to specific battlefield conditions and to the commander's assigned mission in that situation.

The purpose of the IPB analysis is to determine and evaluate OPFOR capabilities, vulnerabilities, and possible courses of action as the basis for own force operations planning. The analysis permits the intelligence analyst to "see" the battlefield area of interest, evaluate possible OPFOR courses of action, determine the events that can be observed as the action unfolds for each OPFOR course of action, and develop an intelligence collection plan that will provide timely information to the commander. The analysis also permits the commander to see the battlefield area of interest in terms of enemy capabilities and possible courses of action, as well as the effects of terrain and weather factors on friendly possible courses of action to accomplish the mission. However, IPB does not provide tools for evaluating the relative impact of such factors or for assessing the likelihood of alternatives. The intelligence aid described in this report is one tool which may be used for these purposes.

The ENCOA procedures described in this manual are designed to be executed entirely by hand or by using an HP41-C or HP41-CV handheld calculator for the more complex numerical computations when the required manual procedures have been completed.

DESCRIPTION AND OVERVIEW OF THE ENCOA AID

The ENCOA aid can be used by the staff intelligence officer (G2/S2) and supporting intelligence analysts to evaluate alternative enemy courses of action in tactical situations. Its use assumes that the enemy's intent (e.g., attack, defend) and the objective of that intent have been determined. Given these conditions, and knowledge of the size and disposition of the opposing forces, the terrain, and the forecasted weather, the analyst can formulate alternative enemy courses of action for evaluation. This aid will help the analyst look at the battlefield from the perspective of the enemy commander in order to select the most likely alternatives from among those formulated.

The ENCOA aid is based on the simple but well-established procedures of multiattribute utility assessment. These procedures are based on the assumption that it is easier to break a problem down into its component parts, solve the component problems, then aggregate back to the original problem. The ENCOA aid breaks the overall problem of assessing the relative likelihood of enemy courses of action into a series of steps which require an analyst to evaluate possible enemy courses of action on 25 component factors which are organized into five mutually exclusive categories, as shown in Figures 2 and 3. These component evaluations are then combined to produce an assessment of the overall relative likelihood of the enemy courses of action. This allows analysts to evaluate information logically, one factor at a time, thus decreasing the memory load and ensuring that all relevant information is considered.

Steps for using the ENCOA aid are outlined in Figure 1. First the analyst must define and describe the reasonable courses of action (or avenues of approach, corridors of mobility, etc.) that the enemy may pursue. These should be defined such that the enemy can only pursue one avenue at a time. In step 2, information on 25 terrain, force, weather, and risk factors (Figure 2) is gathered or made readily available. Now the analyst is ready to evaluate the information numerically and to determine the relative likelihood of each course of action defined in the first step. In step 3 the numerical evaluation of the information is made by answering three questions: (a) how advantageous is each course of action on each factor for the enemy; (b) how important are the factors within each category, e.g., Fields of Fire within the Terrain category; and (c) how important is each category to the overall success of the enemy mission. In step 4, the analyst calculates an overall score for each course of action; the score represents the relative desirability of that course of action for accomplishing the enemy's mission. In step 5 the relative probability of the enemy pursuing each course of action is inferred from the overall scores calculated in step 4.

The algorithms involved in the calculation of the overall values of the alternative courses of action are simple and straightforward. The steps required to make these calculations are described in detail beginning on page 18. While the arithmetic may be tedious, it can be completed by hand in 5-15 minutes with practice. With the worksheets supplied with this manual, evaluation of enemy courses of action can be completed in a field environment with no additional equipment.

summary of steps

As an alternative to manual calculation of the overall values, the ENCOA algorithm has been implemented on the Hewlett-Packard HP41-C/HP41-CV handheld calculator. The steps required to use this program are described in detail beginning on page 25. It is suggested that the beginner work through the procedure manually before attempting the calculator version to gain an understanding of the process by which the scores are aggregated.

The ENCOA aid and calculations are also available for the Apple II Plus and the IBM 5110 and 5120 desktop computers. Procedures for executing an ENCOA evaluation on these computers are outlined in Intelligence Aid for Evaluating Enemy Courses of Action (ENCOA): Manual for Use on Apple II Plus and IBM 5110/5120 Computers (ARI Research Product 83-10).

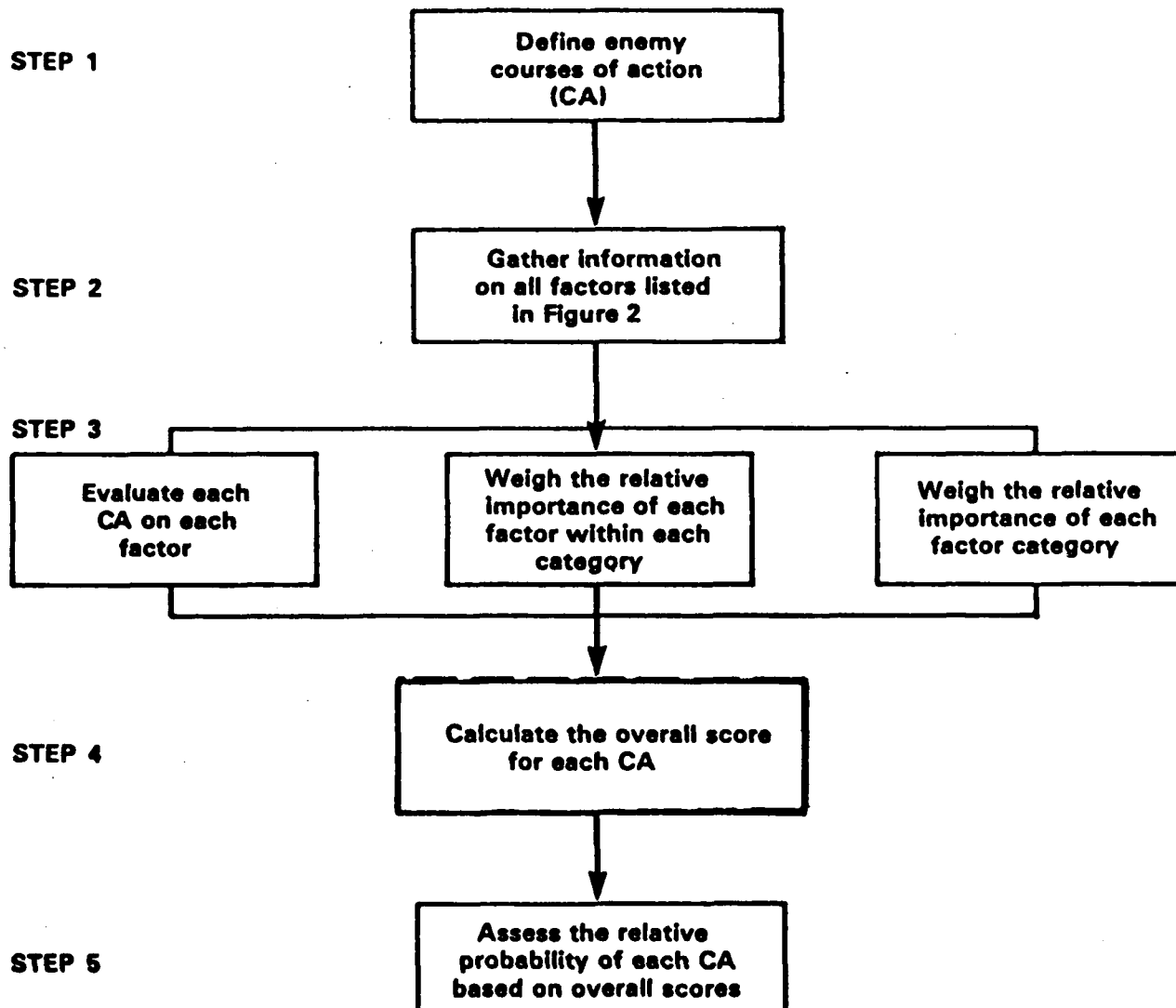


Figure 1. Summary of steps for evaluating the relative likelihood of enemy courses of action.

hierarchy of factors

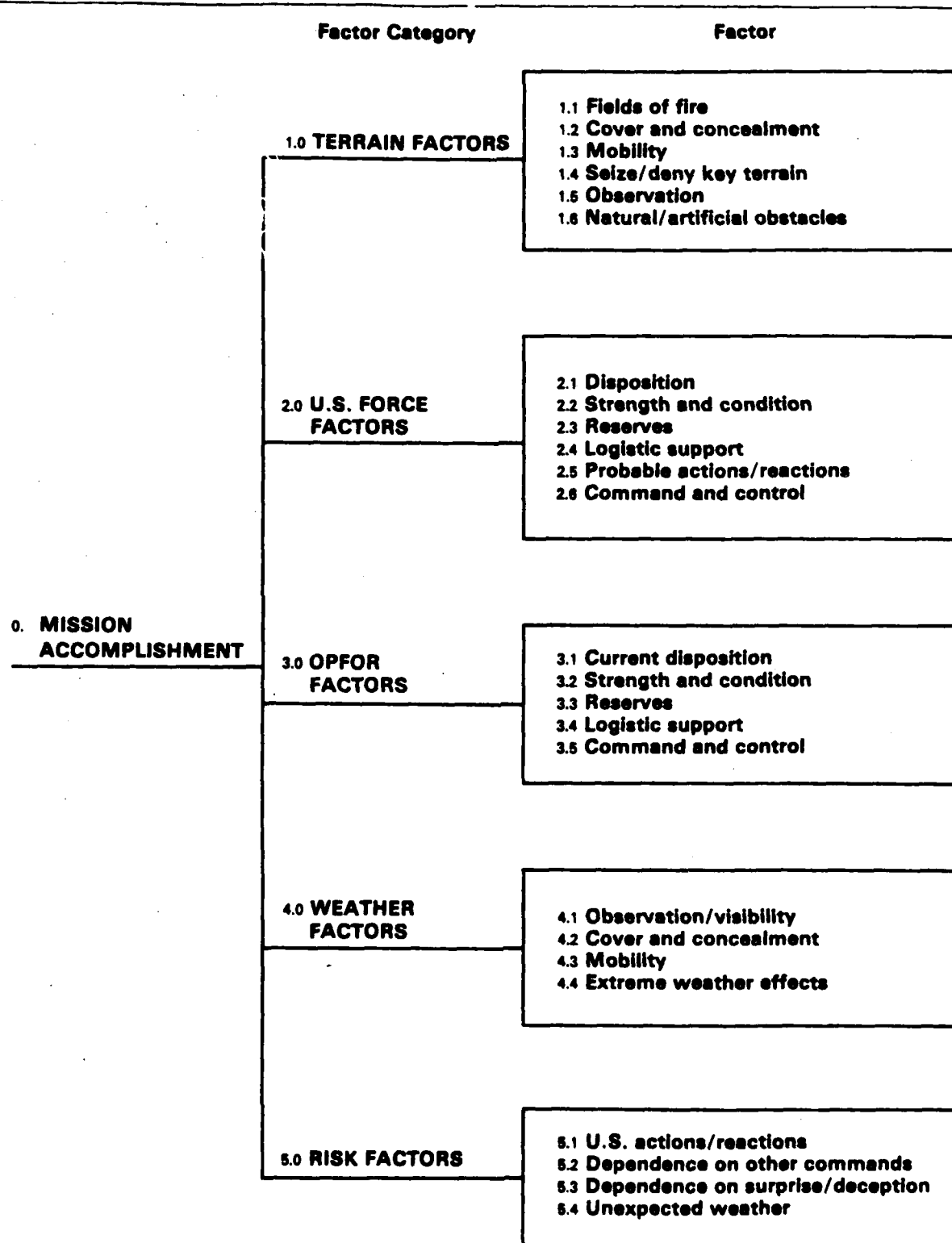


Figure 2. Hierarchy of factors.

criteria for evaluation

1.0 TERRAIN FACTORS

As related to mission accomplishment and considering current OPFOR doctrine, score each OPFOR course of action in terms of how well it

- 1.1 Exploits field of fire afforded by terrain features.
- 1.2 Exploits cover and concealment afforded by terrain features.
- 1.3 Exploits mobility provisions due to terrain features.
- 1.4 Accomplishes rapid seizure or denial of key terrain.
- 1.5 Exploits observation provisions of terrain.
- 1.6 Exploits or accommodates natural and artificial obstacles.

2.0 U.S. FORCE FACTORS

As related to mission accomplishment and considering current U.S. doctrine, score each OPFOR course of action in terms of how well it exploits what you know or estimate about

- 2.1 U.S. disposition.
- 2.2 U.S. strength and condition.
- 2.3 U.S. reserves.
- 2.4 U.S. logistic support.
- 2.5 Probable U.S. actions/reactions.
- 2.6 U.S. command and control capabilities/vulnerabilities.

3.0 OPPOSING FORCE FACTORS

As related to mission accomplishment and considering current OPFOR doctrine, score each OPFOR course of action in terms of how well it exploits or accommodates

- 3.1 OPFOR current disposition.
- 3.2 OPFOR strength and condition.
- 3.3 OPFOR reserves.
- 3.4 OPFOR logistic support.
- 3.5 OPFOR command and control capabilities/vulnerabilities.

4.0 WEATHER FACTORS

As related to mission accomplishment, score each OPFOR course of action in terms of how well it exploits

- 4.1 Observation/visibility conditions forecast to exist due to weather.
- 4.2 Cover and concealment conditions forecast to exist due to weather.
- 4.3 Mobility conditions forecast to exist due to weather.
- 4.4 Effect of extreme conditions of forecast weather on personnel and equipment effectiveness.

5.0 RISK FACTORS

As related to mission accomplishment, score each OPFOR course of action in terms of

- 5.1 Ability to cope with surprises in terms of U.S. strength or U.S. actions/reactions.
- 5.2 Freedom from dependence on forces not under our own control.
- 5.3 Freedom from critical dependence on surprise or deception.
- 5.4 Suitability under unexpected adverse weather conditions.

Figure 3. Criteria for evaluating enemy courses of action on 25 factors.

USING THE AID: EVALUATING THE CAs AGAINST THE FACTORS

The following sections describe the guidelines and procedures for using this intelligence aid in evaluating alternative enemy courses of action (CAs). The sequential steps in the process are as follows:

1. Create a list of specific, viable, alternative enemy courses of action to be evaluated.
2. Gather information on 25 factors which might influence the enemy courses of action.
- 3a. Assess the relative value (with respect to enemy mission accomplishment) of each CA on each of the 25 factors.
- 3b. Within a given factor category, assess the relative importance (weight) of each factor in terms of its contribution to overall enemy mission accomplishment.
- 3c. Assess the relative importance (weight) of each factor category in terms of its contribution to overall enemy mission accomplishment.
4. Calculate the overall score for each enemy CA being evaluated.
5. Assess the probability of each alternative course of action based on the overall scores.

Selecting Alternative Enemy Courses of Action for Evaluation

Formulating alternative enemy courses of action is a crucial step to the quality of the ensuing evaluation. If the most likely (best from the perspective of the enemy commander) enemy CA is not formulated for inclusion in the evaluation process, it obviously cannot be so identified by any methodology. Unlikely or unrealistic alternatives, if included in the evaluation, may distort the required subjective value and importance judgments because of the extreme differences between these weak alternatives and the more realistic alternatives.

In selecting alternative enemy CAs for evaluation, follow these guidelines:

- o The list of alternatives selected should be exhaustive, in that it includes all those under serious consideration. The key assumption here is that one of the selected alternatives will in fact be chosen by the enemy commander as a course of action.
- o The alternatives selected should be mutually exclusive and independent. The selection of one alternative course of action by the enemy commander should preclude the implied selection of another.
- o The selected alternatives should be reasonable. Alternatives that are impossible to implement, or are so impracticable that they would not be selected under any circumstance, should not be included in the evaluation.

There are no formal limits to the number of alternative courses of action that can be included in the evaluation, but, in general, three to five alternatives, selected in accordance with the above guidelines, should be retained for evaluation. The alternatives chosen should be listed at the top of the ENCOA data sheet, shown reduced in Figure 4.

FACTOR SCORING

The data sheet used for scoring the alternative enemy courses of action being evaluated is shown full-size in Figure 5. Courses of action selected for evaluation have been listed at the top for ready reference during the assessment process. For each of the 25 factors, the alternative courses of action are scored using the following rules and procedures, referring as necessary to the considerations listed in Figure 3.

1. Identify the CA which is best with respect to the given factor and assign this alternative a relative score of 100 by entering its number (1, 2, etc.) over 100 on the scoring scale for the factor. If two or more CAs are tied as best on the factor, they should each be scored 100 by entering their numbers over 100 on the scoring scale. If all CAs being evaluated are equally good, assign a score of 100 to each and skip steps 2 and 3. Remember, "best" means the most advantageous CA for the enemy to pursue in order to accomplish their mission.

2. Identify the CA which is worst with respect to the given factor and assign this CA a relative score of 0 by entering its number over 0 on the scoring scale for the factor. If two or more CAs are tied as worst on the factor, they should each be scored 0 by entering their numbers over 0 on the scoring scale.

3. Having identified the best and worst CAs in the previous steps, assign relative scores for the remaining CAs by entering the CA numbers over the desired scores on the 0-100 scale for the factor. These scores should reflect your judgment of the desirability or value of each CA relative to the best and worst CA alternatives.

When the scoring has been completed for all of the factors, the data sheet will resemble that of the sample evaluation shown in Figure 5, which continues on page 10.

CA1: R-HI-----

CA2: L-HI-----

CA3: L-LO-----

CA4: -----

CA5: -----

0. MISSION ACCOMPLISHMENT

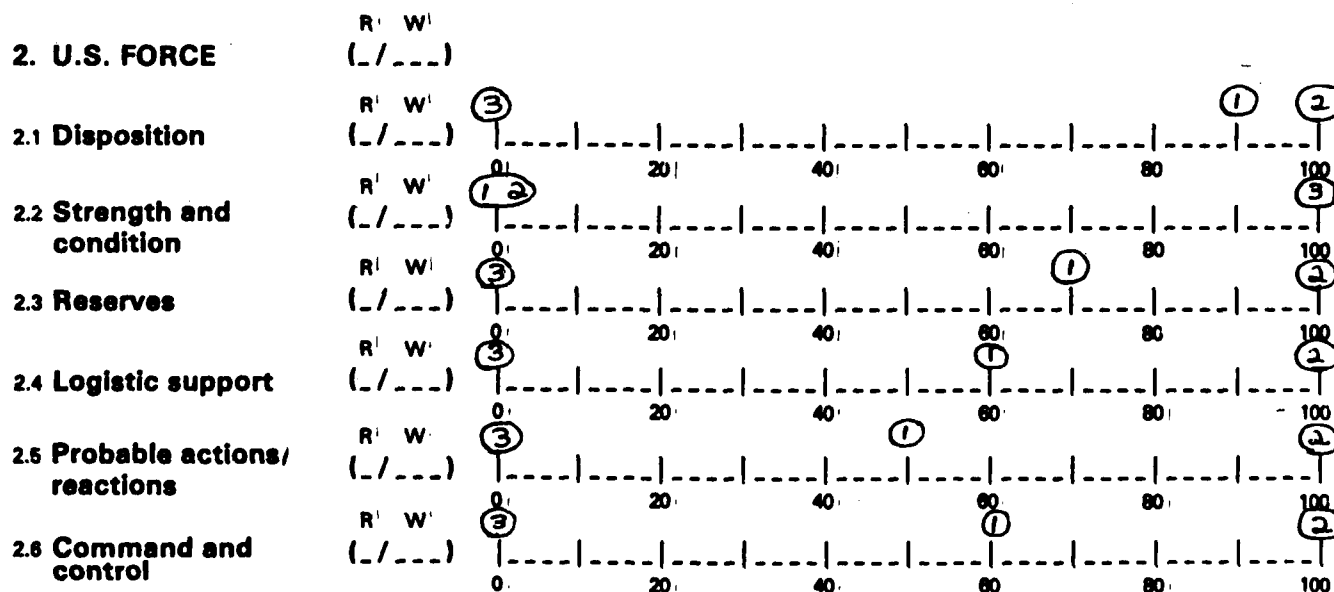
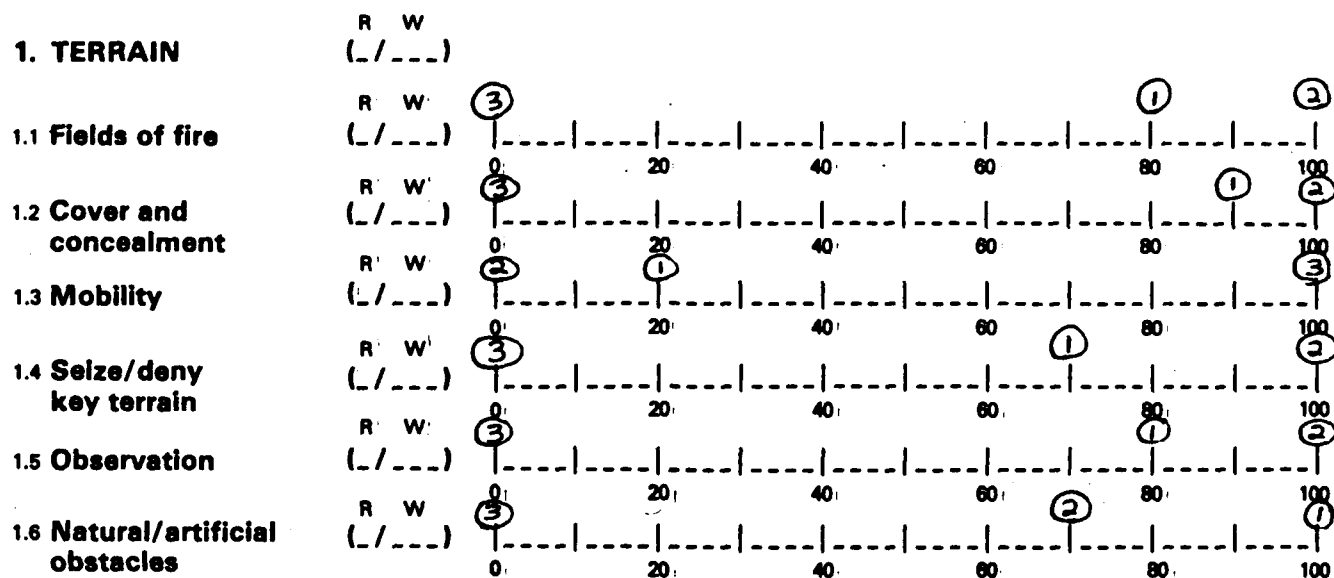
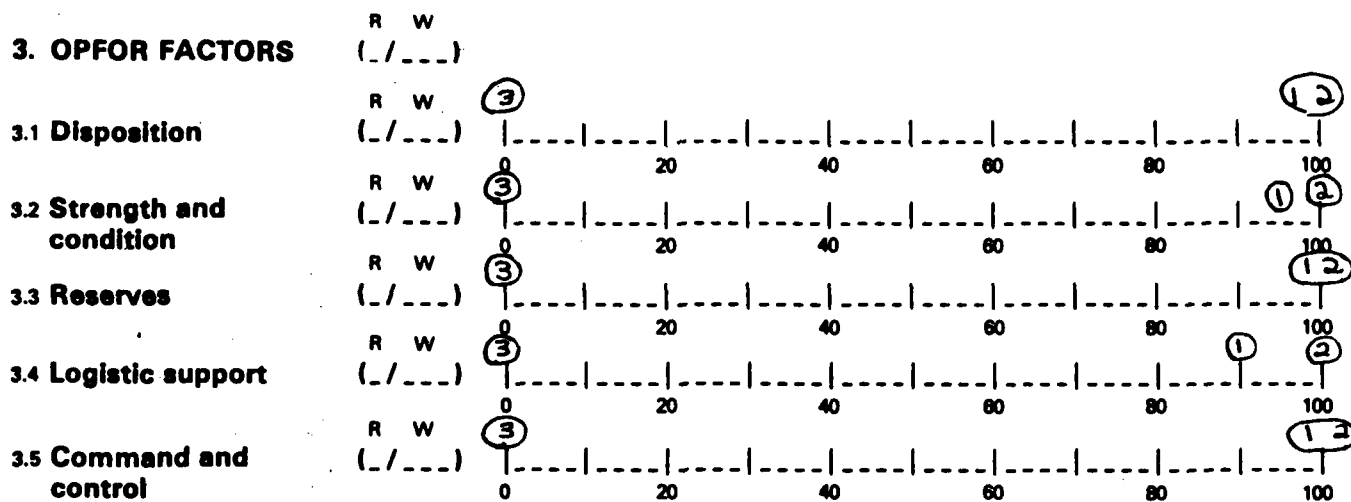
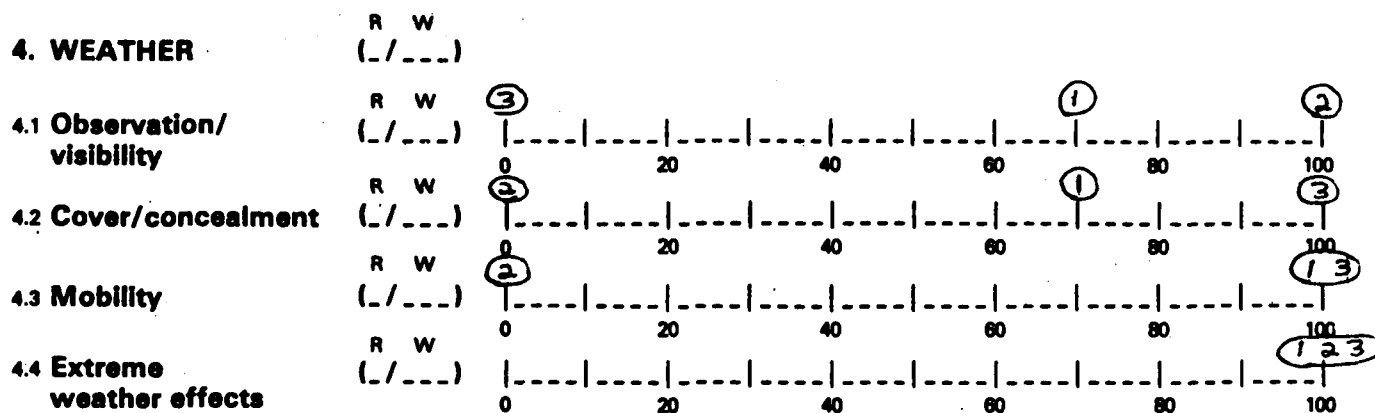


Figure 5. ENCOA data sheet with factor scores recorded.

3. OPFOR FACTORS



4. WEATHER



5. RISK

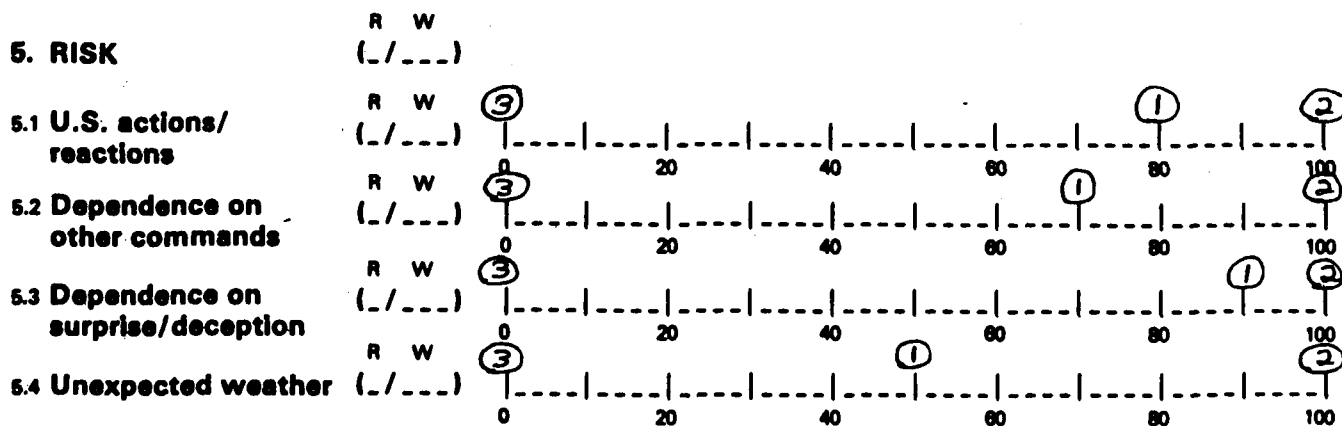


Figure 5 continued.

FACTOR WEIGHTING

After scoring each alternative course of action on each factor, the next step is to assign weights to each factor within a particular factor category (i.e., terrain, weather, etc.). The weights you assign should show, for that factor, how much the difference between the poorest and best course of action really matters in terms of mission accomplishment. Some differences between courses of action may be large but of little importance. Others may be small but highly important. In assigning weights, you are judging how important the improvement is between the poorest and best courses of action for each factor. Use the same data sheet on which you scored the course of action alternatives for the assignment of weights, utilizing the column of parentheses between the factor titles and scoring scales marked R/W, for rank/weight. Assign each factor in each factor category a weight, using the following procedures.

1. Rank the factors within each factor category in terms of the importance of the difference between the best and worst courses of action shown for each factor. Ask yourself, "How much does the difference between the best and worst course of action shown on the scoring scale for each factor really matter?" Enter the number 1 in the parentheses under R for the factor that you judge to be the most important differentiating factor. Enter 2 under R for the factor judged next in importance. Continue until you have ranked all of the factors in the particular factor category. When you have completed the ranking of the factors, enter a weight of 100 in the parentheses under W for the factor judged to be most important, i.e., the factor you ranked 1.

2. Assign weights to each remaining factor in the factor category. To do this, consider the most important factor--the one you ranked number 1 in terms of how much the difference between the poorest and best course of action would matter. With that as a reference, consider the factor you ranked as second most important. Ask yourself, "Relative to the most important factor and its weight of 100, how much is the difference between the poorest and best courses of action for the second factor worth? Does that difference matter only half as much? Ten percent as much? Ninety percent as much?"--and so on. When you decide on its percentage worth relative to the first one, assign that weight; that is, if you think it is 80 percent as important as the first difference, enter a weight of 80. Use the same thought process to assign weights to all the factors. Remember, you are weighing how much the difference between best and worst courses of action for each factor matters in terms of mission accomplishment--not simply how important a factor might be generally or how big a difference there might be between courses of action for a given factor. If, in your judgment, some of the factor differences are equally important, assign the same weights to those factors. Any factors on which all CAs have been scored 100, implying no difference in terms of mission accomplishment, are assigned a weight of 0.

3. Repeat steps 1 and 2 for each of the remaining factor categories.

factor weighting (continued)

When weights have been assigned to all of the factors, the data sheet will resemble that for the sample evaluation shown in Figure 6. Take, for instance, the six factors in the terrain category. For factors 1.1, 1.2, 1.4, and 1.5, the rank order of the courses of action is 2, 1, 3. CA2 is scored as 100 for all four factors; CA3 is scored as 0 for all four factors; CA1 is assigned a score of 80 for three of the factors and 70 for one of them. For factors 1.3 and 1.6, the factors are ranked 3, 1, 2 and 1, 2, 3, respectively. The best and worst CA for each of these two factors receive scores of 100 and 0, respectively. For factor 1.3, CA1 receives a score of 20; for factor 1.6, CA2 receives a score of 70. The factors have been ranked 1.4, 1.5, 1.1, 1.2, 1.6, 1.3 in terms of the importance of the difference between the best and worst course of action for each factor. The weights assigned to the factors in the above order are 100, 90, 80, 65, 50, and 20, respectively.

CA1: R-H1.....
 CA2: L-H1.....
 CA3: L-L0.....
 CA4:
 CA5:

0. MISSION ACCOMPLISHMENT

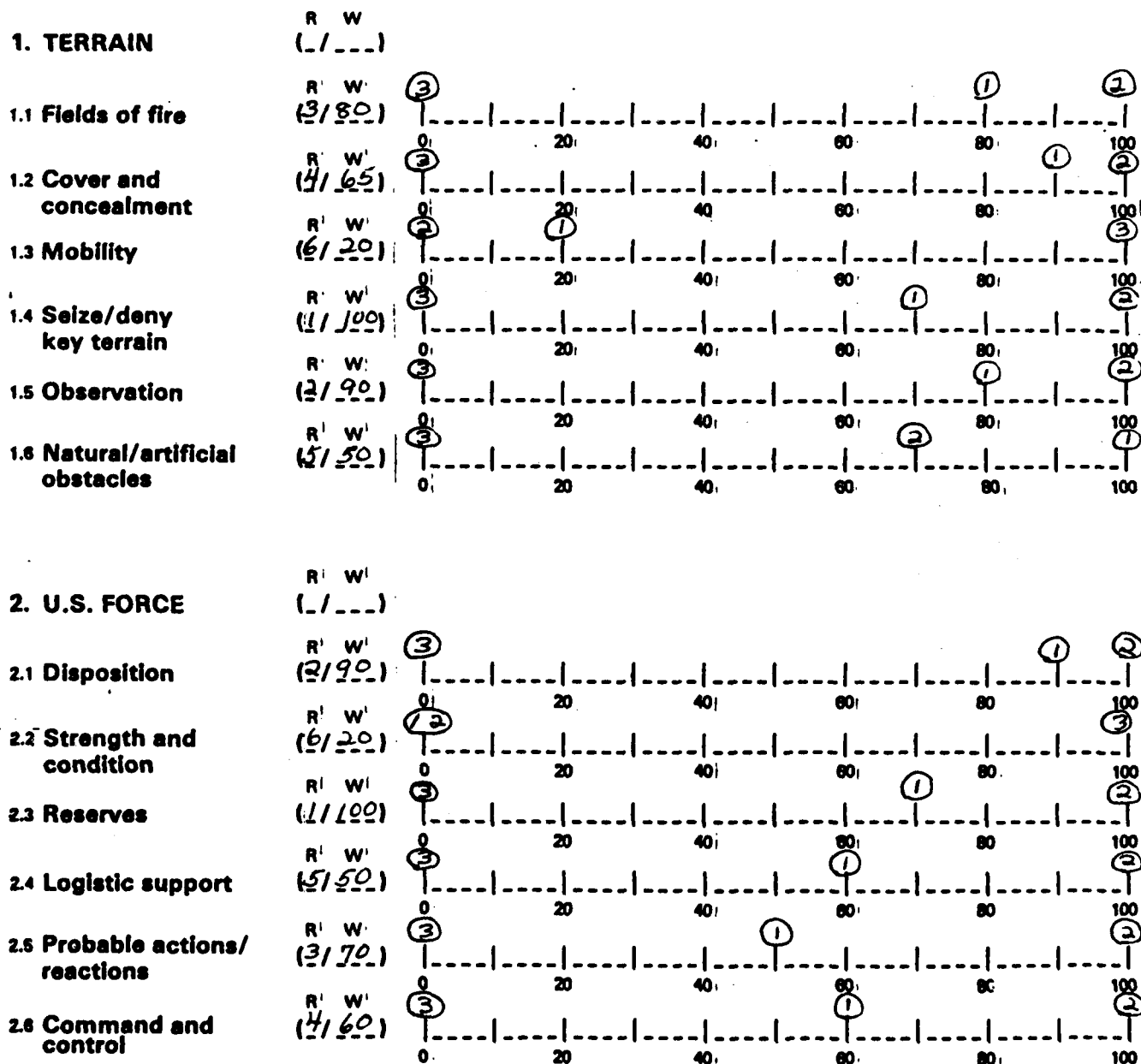
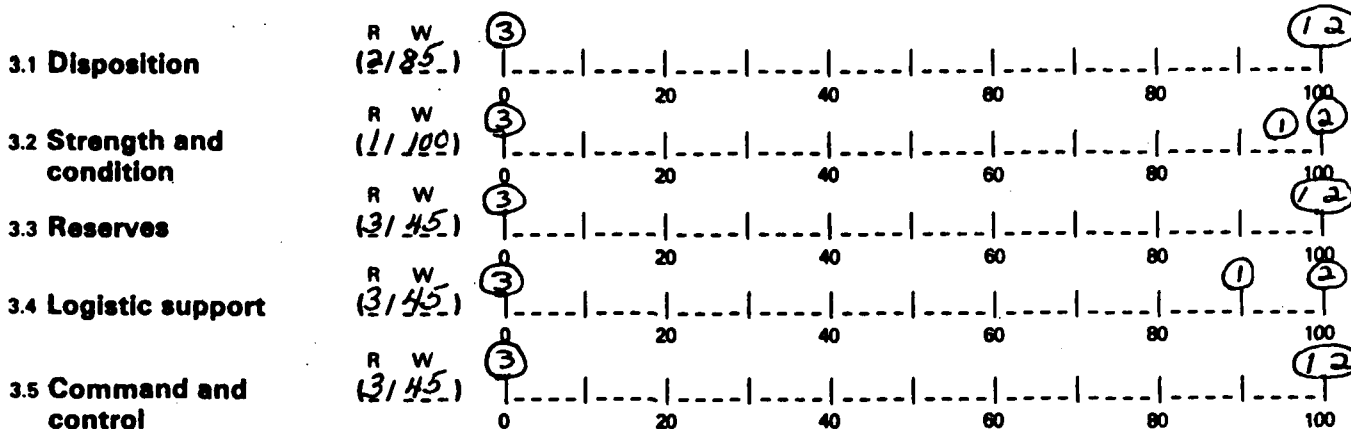
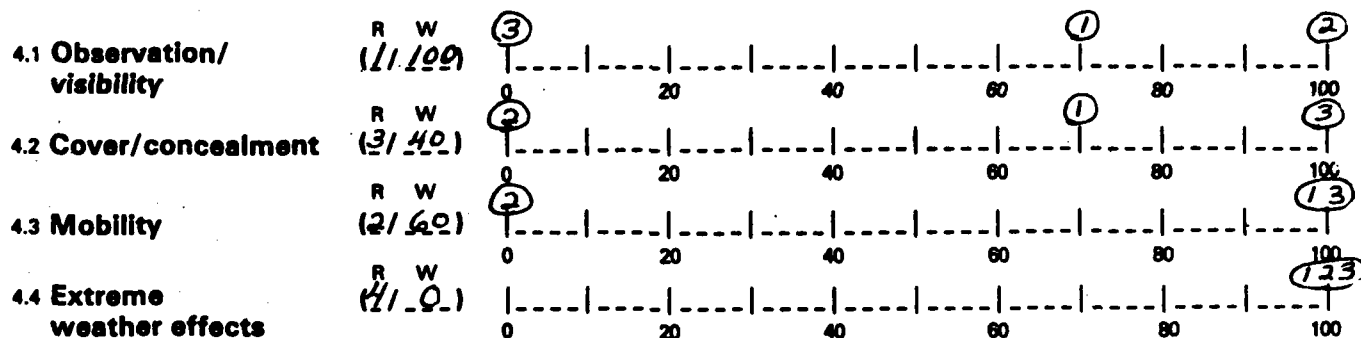


Figure 6. ENCOA data sheet with factor weights recorded.

3. OPFOR FACTORS



4. WEATHER



5. RISK

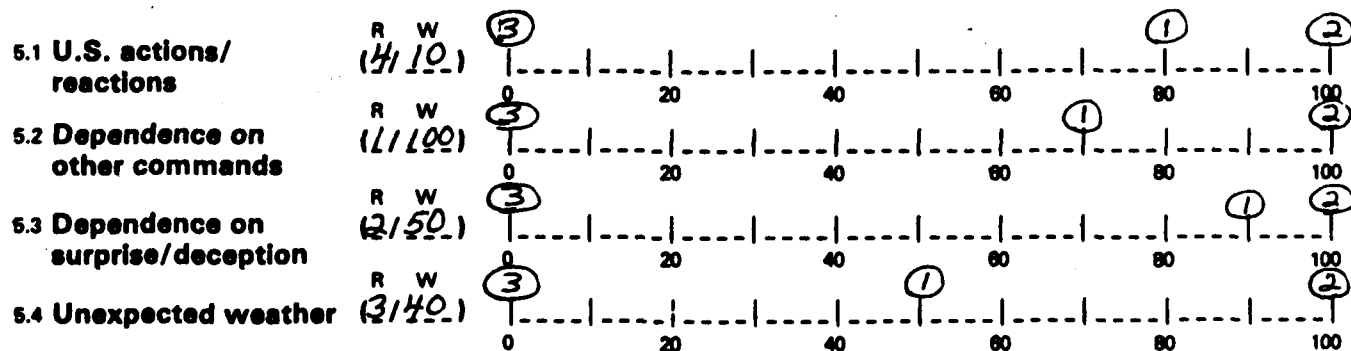


Figure 6 continued.

FACTOR CATEGORY WEIGHTING

You have now scored the alternative courses of action against all the factors and weighted those factors in terms of how important they are in differentiating between courses of action. The final step is to determine the importance of each factor category in terms of mission accomplishment.

Using the data sheet, identify the most important factor in each category, the factor ranked 1 and assigned a weight of 100. Now rank order the factor categories in terms of the importance of the difference between the best and worst courses of action on these five factors. Enter the rank assigned under R in the parentheses which are adjacent to the factor category titles. When the ranking has been completed, enter a weight of 100 under W for the factor category judged to be the most important.

Next, assign importance weights to the remaining factor categories using the judgment process of step 2 in weighting the individual factors.

In cases where two factors in a factor category have been judged to be equally most important (weight = 100), either may be used in assigning weights to the factor categories. As a check on your subjective judgment concerning these equally important factors, it is advisable to weight the factor categories using each in turn. If the resulting relative weights for the factor categories differ, this indicates a differential rather than equal importance for the two factors. The weights for these two factors should be reassessed to reflect this differential importance before proceeding further in the evaluation.

When this step has been completed, the data sheet will resemble that for the sample evaluation shown in Figure 7. All of the scores and weights have been assessed, and the overall value of each alternative course of action can be calculated.

CA1: *B-HI*-----
 CA2: *L-HI*-----
 CA3: *L-LO*-----
 CA4: -----
 CA5: -----

0. MISSION ACCOMPLISHMENT

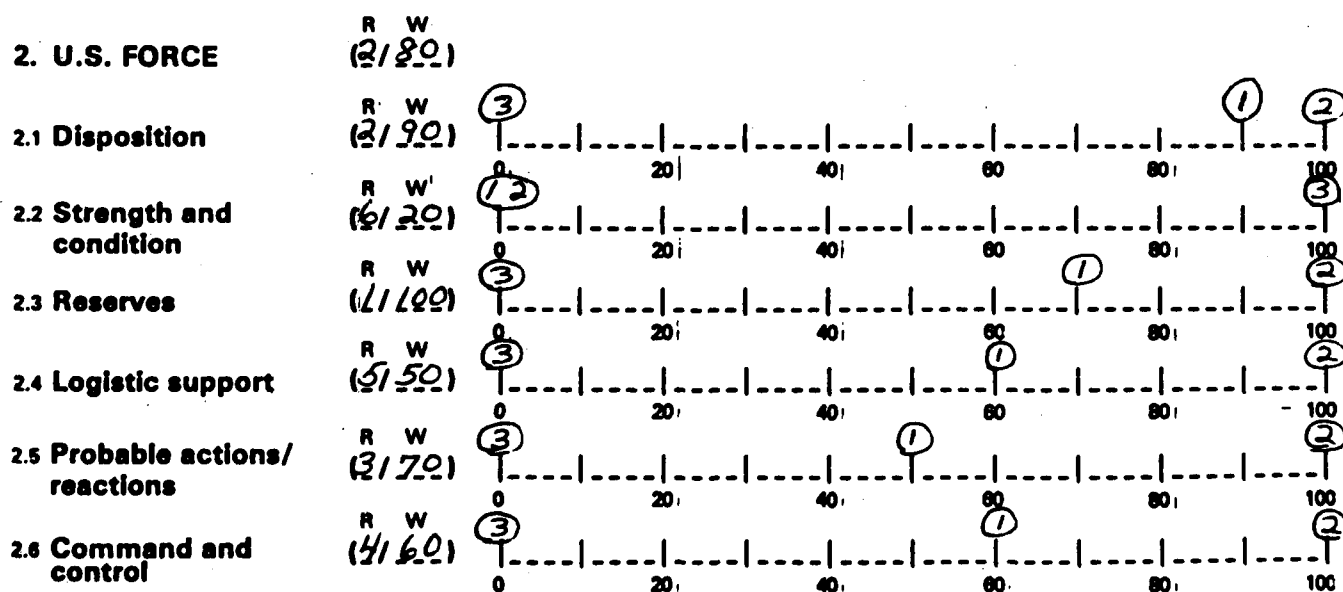
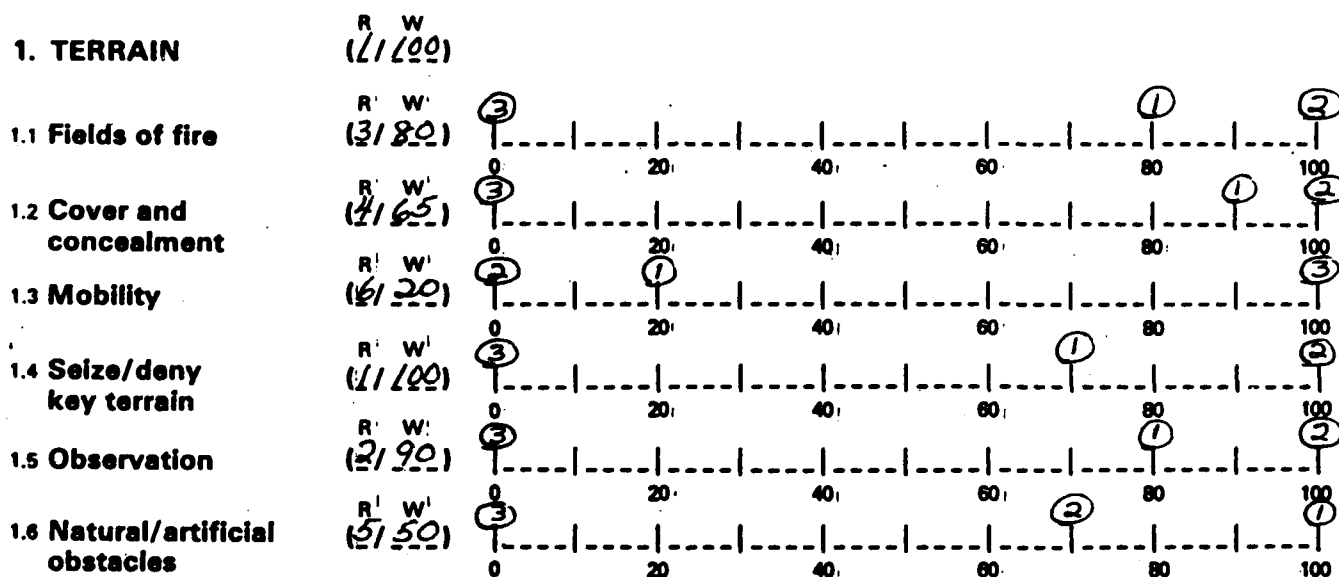
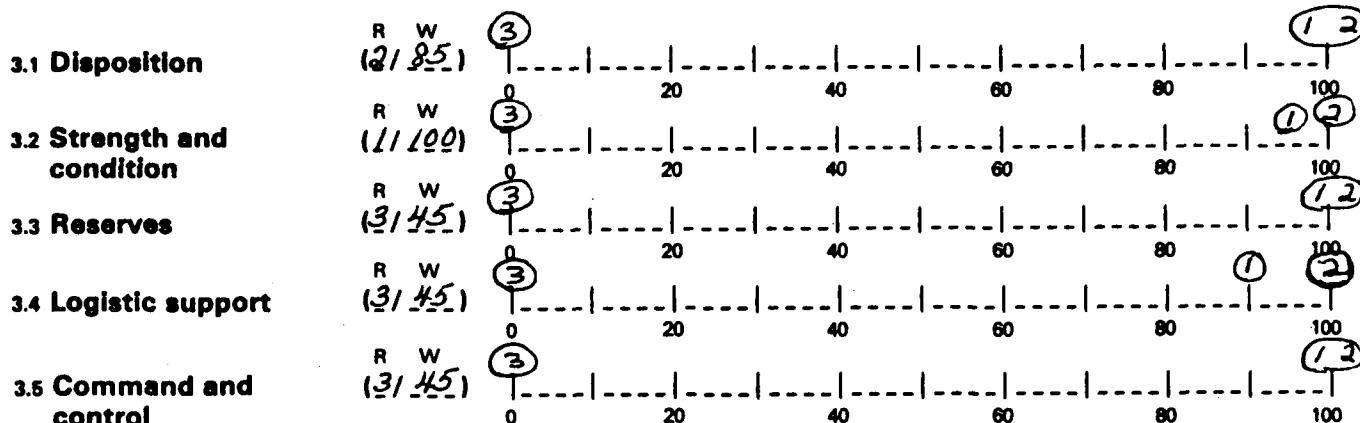
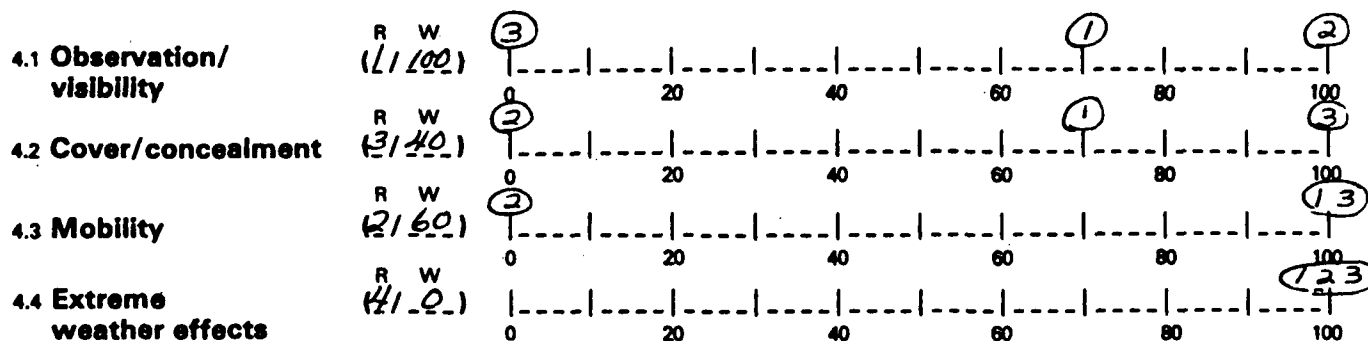


Figure 7. ENCOA data sheet with factor category weights recorded.

3. OPFOR FACTORS R W
(4/30)



4. WEATHER R W
(51-51)



5. RISK R W
(3/60)

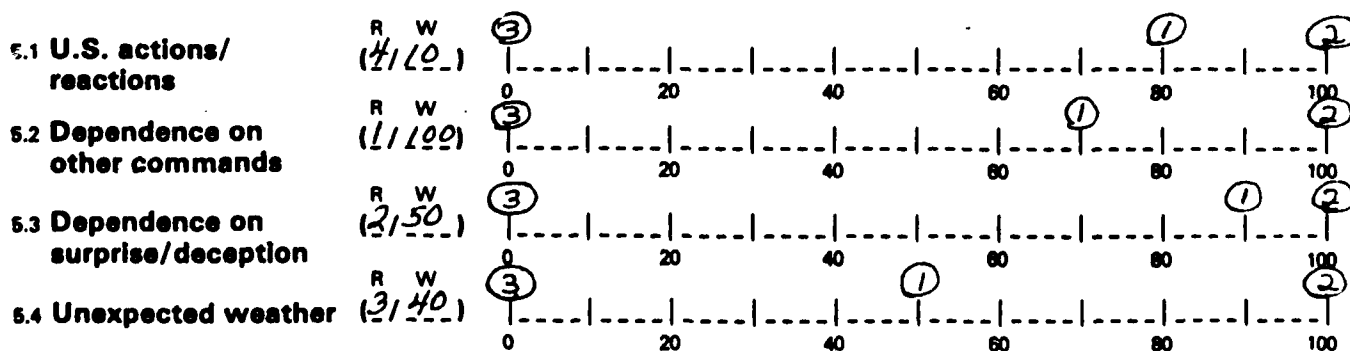


Figure 7 continued.

CALCULATING OVERALL VALUES FOR ALTERNATIVE CAs BY HAND

The calculations begin at the factor level, multiplying the weight for each factor by the assigned score for each alternative course of action (CA) being evaluated to derive a weighted score for each CA on each factor. These scores are aggregated for all factors within a factor category to obtain a weighted score for each CA at the factor category level. These scores and the assigned importance weights for each factor category are then used to derive a weighted score for each CA on each factor category. Aggregation of this set of weighted scores provides the overall score with respect to mission accomplishment for each alternative course of action being evaluated.

If this procedure were followed literally, the resulting values at the mission accomplishment level would become quite large, possibly five-digit numbers or even larger. Also, while the lower end of the value scale remains fixed at zero, the upper end of the value scale is not readily apparent.

Since the original scoring of the factors was done using a 0-100 scale, constraining the aggregated score for each factor category to a maximum of 100 would facilitate judgments of the relative merit of the CAs. The following sections, describing the steps in calculating the overall values for the alternative courses of action, will show how this is accomplished.

Calculating Factor Category Scores for Alternative Courses of Action

The first step is to transfer the relative weight for each factor from the data sheet (Figure 7) to the relative weight column (Rel under Weight) of the calculation sheet for its factor category. Figure 8 is the calculation sheet for the Risk Factor category of the sample evaluation and will be used to illustrate the calculation procedures. (Each evaluation requires six calculation sheets, one for each of the five factor categories and one for mission accomplishment.) The sum of all the relative weights should be entered in the total row at the bottom of the relative weight column (e.g., 200 in Figure 8).

The next step is to normalize the relative weights, i.e., constrain the weights to add up to 100 by dividing the relative weight for each factor by the total relative weight and multiplying the result by 100. In the Figure 8 example, the relative weight of 10 for Factor 5.1 is divided by the total relative weight of 200 and then multiplied by 100 to result in the normalized weight of 5. The resulting value for each factor should be rounded to the nearest whole number and entered in the normalized weight (Norm) column for that factor. The sum of the normalized weights within each factor category should equal 100. Because of rounding, the sum may not always equal 100. If there is a significant difference, recheck calculations before proceeding. The process of normalization has converted the relative weight for each factor into the percent contribution each factor makes to the total factor category score for each CA being evaluated, without changing the relative relationship originally assessed.

Now transfer the relative score for each CA on each factor from the data sheet (Figure 7) to the appropriate relative score column (Rel under Scores). (The relative scores for CAs 1, 2, and 3 on the 5.1 factor are 80, 100, and 0, respectively.) When all of the relative scores have been entered, the weighted score for each CA on each factor is calculated by multiplying the relative

CATEGORY: RISK FACTORS

ID#	FACTOR	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
		Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
5.1	U.S. ACTIONS/REACTIONS	10	5	80	4	100	5	0	0				
5.2	DEPENDENCE ON OTHER COMMANDS	100	50	70	35	100	50	0	0				
5.3	DEPENDENCE ON SURPRISE/DECEPTION	50	25	90	22	100	25	0	0				
5.4	UNEXPECTED WEATHER	40	20	50	10	100	20	0	0				
	TOTAL	200	100		71		100		0				

Abbreviations

Rel - relative

Rel - relative Wtd - weighted
Norm - normalized Wt - weight

$$\text{Norm Wt} = \frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$$

Calculations

$$\text{Wtd Score} = \frac{\text{Rel Score} \times \text{Norm Wt}}{100}$$

Figure 8. Factor category calculation sheet.

calculating mission accomplishment scores

score for each CA by the normalized weight of the factor and dividing the result by 100. Thus, in Figure 8, CA1 gets a weighted score of 4 on Factor 5.1 by multiplying the normalized weight of 5 by the relative score of 80 and dividing the resultant 400 by 100. Similarly, the remaining risk factors have weighted scores of 35, 22, and 10 for CA1.

When the weighted scores have been calculated and entered on the calculation sheet for each CA on each of the remaining factors, the sum of the weighted scores for each CA should be entered in the total row at the bottom of the weighted score column. In the Figure 7 example, CA1 has a total weighted score of 71, while CA2 and CA3 have scores of 100 and 0. While total weighted scores should be values between 0 and 100, there is no requirement that any of them actually equal 0 or 100.

The procedure above should be used to calculate weighted factor scores and their totals (aggregated factor category scores) for the remaining factor categories, before proceeding to the next step. (The Appendix contains completed calculation sheets for factor categories 1-4.)

Calculating Mission Accomplishment Scores for Alternative Courses of Action

As in the previous section, the initial step is to transfer data from the data sheet, in this case moving the relative weight for each factor category to the relative weight column (Rel under Weight) on the Mission Accomplishment calculation sheet (Figure 9). As before, sum the relative weights, enter the total at the bottom of the column, and normalize each factor category relative weight (divide it by the total and multiply the result by 100). Again, the sum of the normalized weights should equal or approximate 100.

Next, transfer the aggregated score (total) for each CA from the factor category calculation sheet to the appropriate row of the factor category score column (FCS) on the Mission Accomplishment calculation sheet. Compute the weighted score for each CA on each factor category by multiplying the normalized weight by the FCS and dividing by 100. When these calculations are completed, sum the weighted scores for each CA and enter this value in the total row. The resulting numbers are the overall relative values, on a scale of 0-100, of each of the CAs under consideration with respect to mission accomplishment.

The total (cumulative weighted) scores shown in Figure 9 indicate that CA2 is the best alternative course of action and should, therefore, be considered the most likely enemy course of action. CA1 is next best, not that much worse than CA2, and probably should be included in any further analysis and in the intelligence collection planning. CA3 is so low in value that it is not a likely enemy course of action and probably should be disregarded.

The complete set of calculation sheets contains all of your subjective judgments and implications at factor, factor category, and mission accomplishment levels, and provides an excellent vehicle for reviewing these judgments and their impacts before reaching a final conclusion on the hypothesized enemy courses of action.

ID#: 0 CATEGORY: MISSION ACCOMPLISHMENT

FACTOR CATEGORY		Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
ID#	Name	Rel	Norm	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd
1.0	TERRAIN	100	36	79	28	91	33	6	2				
2.0	U.S. FORCES	80	29	65	19	95	28	5	1				
3.0	OPPOSING FORCES	30	11	97	11	100	11	0	0				
4.0	WEATHER	5	2	79	2	50	1	50	1				
5.0	RISK	60	22	71	16	100	22	0	0				
	TOTAL	275	100		76		95		4				

Abbreviations

Rel - relative Wtd - weighted
 Norm - normalized Wt - weight
 FCS - factor category score

Calculations

Norm Wt = $\frac{\text{Factor Category Rel Wt}}{\text{Total Rel Wt}} \times 100$

Wtd Score = $\frac{\text{FCS} \times \text{Norm Wt}}{100}$

Figure 9. Mission accomplishment calculation sheet.

SUMMARIZING AND INTERPRETING YOUR CALCULATIONS

While the calculation of the relative worth of possible enemy courses of action in the previous section is the focus of the ENCOA intelligence aid, the individual judgments and weights can also give you insight into your judgment processes. As you become more facile with assigning weights and values, you will undoubtedly begin to develop your own system for interpreting your analysis. This section presents guidelines for helping you gain greater insight into your analysis of enemy courses of action.

Interpreting your scores. The scores you assign to each course of action on each of the 25 factors are listed both on the data sheet and in the relative score column on the factor category calculation sheets (see examples in Appendix). You should examine these scores to see if you consistently rate a course of action best or worst on most factors. A quick scan of these scores may reveal that one or more of the courses of action are so poor on most of the factors that they really aren't viable enemy courses of action. Be wary of creating a course of action simply to have more alternatives to evaluate. By contrast, a particular course of action may have appeared to be a real possibility at the beginning of an analysis, but have been discredited as a viable alternative by your systematic evaluation.

This same logic applies to alternatives which are judged to be best on most factors. Scrutinizing the courses of action on all factors may show one to be clearly dominant; that is, one course of action may be consistently the best on most factors. It may well be that, by conducting your analysis factor-by-factor, the choice becomes much clearer. Do not deceive yourself, however, in thinking that the problem was very clear before you conducted your analysis; never underestimate the power of hindsight to be correct.

Your ENCOA analysis can also be used effectively to justify your selection of enemy courses of action or to show a commander why a particular course of action is extremely unlikely or likely. The systematic evaluation required by the ENCOA procedures not only allows you to better understand your own judgments, but also provides you with explanations of your analysis that others can easily understand.

Interpreting weights

Interpreting your weights. To facilitate studying the relative importance of the factors, calculate the weight of each factor relative to all 25 factors. To compute this weight use the Summary of Normalized Weights Calculation Sheet (Figure 10).

So far you have calculated two levels of weights, the weight of each category (e.g., Terrain, U.S. Forces, etc.) and the weight of the factors within each category. Use these two types of weights to calculate the weight of each factor regardless of its category. Follow these steps:

1. Transfer the normalized category weights from the Mission Accomplishment Calculation Sheet (Figure 9) to the Summary of Normalized Weights Sheet (Figure 10).
2. Transfer the normalized factor weights within each category from the Factor Category Calculation Sheet (Figure 8) to the Summary of Normalized Weights Sheet.
3. To obtain the normalized factor weights (total) regardless of category, multiply the category weight by each normalized factor weight (within category), divide the product by 100, and round to the nearest whole number. For example, the normalized factor weight (total) for Fields of Fire factor in Figure 10 is:

$$(36 \times 20)/100 = 720/100 = 7.2, \text{ which rounds to } 7.$$

4. Repeat step 3 for each factor in each category. The sum of the normalized factor weights (total) should equal 100.

The normalized factor weight column in Figure 10 reveals the relative importance of each of the 25 factors taking into account the relative importance of each category. You may now compare the relative importance of each factor to every other factor regardless of its category. That is, Factor 1.1, Fields of Fire, has an importance of 7% of the total 100 points; Factor 1.2, Cover and Concealment, is 6% of the total; and so on. It may be helpful to put the most important five factors in order of decreasing importance. A quick scan may reveal that perhaps half of the factors are not important at all, accounting for only perhaps 5-10% of the total 100 points. This shortened list should help you focus on the factors which are very important in deciding the relative likelihood of possible enemy courses of action. You may want to recheck the values you assigned to the most important factors to be sure of their accuracy or request additional data to reevaluate these factors.

These calculations, based on your own judgment and analysis, can give you guidance in developing or modifying your collection plan. There may be some types of information that emerge from your analysis as critical to distinguishing among enemy courses of action, while other types emerge as clearly unimportant. You will now have a firmer basis on which to assign collection resource allocation priorities. Again, the systematic analysis of weights gives you a ready means to explain and justify your analysis to other intelligence analysts or your supervisors or commander.

	Category weight	Normalized factor weights (within cat.)	Normalized factor weights (total)	Top 5 most important factors	Weights
1.0 TERRAIN	<u>36</u>				
1.1 Fields of fire		<u>20</u>	<u>7</u>	1 <u>5.2</u>	<u>11</u>
1.2 Cover & conceal		<u>16</u>	<u>6</u>	2 <u>1.4</u>	<u>9</u>
1.3 Mobility		<u>6</u>	<u>2</u>	3 <u>1.5</u>	<u>8</u>
1.4 Seize/deny key terrain		<u>25</u>	<u>9</u>	4 <u>2.3</u>	<u>8</u>
1.5 Observation		<u>22</u>	<u>8</u>	5 <u>1.1</u>	<u>7</u>
1.6 Nat/art obstacles		<u>12</u>	<u>4</u>		
Total Terrain	=	100			
2.0 U.S. FORCE	<u>29</u>			10 least important factors	
2.1 Disposition		<u>23</u>	<u>7</u>		
2.2 Strength/cond.		<u>5</u>	<u>1</u>		
2.3 Reserves		<u>26</u>	<u>8</u>	1 <u>1.3</u>	<u>2</u>
2.4 Logistic support		<u>13</u>	<u>4</u>	2 <u>3.5</u>	<u>2</u>
2.5 Prob. act/reacts.		<u>18</u>	<u>5</u>	3 <u>3.4</u>	<u>2</u>
2.6 Command/control		<u>15</u>	<u>4</u>	4 <u>3.3</u>	<u>2</u>
Total U.S. Force	=	100		5 <u>2.2</u>	<u>1</u>
3.0 OPFOR	<u>11</u>			6 <u>5.1</u>	<u>1</u>
3.1 Current dispos.		<u>27</u>	<u>3</u>	7 <u>4.1</u>	<u>1</u>
3.2 Strength/cond.		<u>32</u>	<u>4</u>	8 <u>4.3</u>	<u>1</u>
3.3 Reserves		<u>14</u>	<u>2</u>	9 <u>4.2</u>	<u>0</u>
3.4 Logistic support		<u>14</u>	<u>2</u>	10 <u>4.4</u>	<u>0</u>
3.5 Command/control		<u>14</u>	<u>2</u>		
Total OPFOR	=	100			
4.0 WEATHER	<u>2</u>				
4.1 Observ/visibility		<u>50</u>	<u>1</u>		
4.2 Cover & conceal		<u>20</u>	<u>9</u>		
4.3 Mobility		<u>30</u>	<u>1</u>		
4.4 Extreme weather eff.		<u>0</u>	<u>0</u>		
Total Weather	=	100			
5.0 RISK	<u>22</u>				
5.1 U.S. act/reaction		<u>5</u>	<u>1</u>		
5.2 Dep. on other comm.		<u>50</u>	<u>11</u>		
5.3 Dep. on sur/decpt.		<u>25</u>	<u>6</u>		
5.4 Unexpected weather		<u>20</u>	<u>4</u>		
Total Risk	=	100	100	= Total, all factors	

Figure 10. Summary of normalized weights calculation sheet.

CALCULATING OVERALL VALUES FOR ALTERNATIVE COURSES OF ACTION WITH THE HP41-C/HP41-CV CALCULATOR

The ENCOA algorithm has been adapted to the Hewlett-Packard HP41-C and the HP41-CV handheld calculators. The capabilities and procedures are identical using either calculator except for the initial procedure to load the ENCOA software. The ENCOA program allows you to enter and modify factor weights and scores for up to five alternative courses of action. It is capable of performing the basic evaluation method, arriving at an overall weighted solution for each alternative course of action. Also provided is the capability to rank the factor weights in terms of relative importance regardless of their category. Further, using the card attachment, you can store and retrieve models with magnetic data cards. A template is provided with this manual to place over the keyboard after loading the program and before beginning the following analyses.

Calculator Work Sheet

The calculator work sheet, shown in Figure 11, resembles the format of the ENCOA data sheet. Scores and weights should first be entered on the data sheet and then transferred to the calculator work sheet. (Pages 8-17 provide detailed instructions and examples for completing the data sheet.)

Node and reference numbers. Each blank on the calculator work sheet has an associated number to its left. These numbers, 0-155, are reference numbers used to access storage spaces allotted for the data in the calculator's memory. Node numbers 0-3 are calculator reference numbers corresponding to grouped data. For example, Node 1 includes the weights of the factor categories 1-5.

Alternative courses of action. The number of alternative courses of action is entered at Node 0 in blank 0 at the top of the work sheet.

Weights. Blanks 1-30 are used to record the relative weight of each factor.

Scores. Blanks 31-155 are used to record the scores for each alternative course of action. Scores for up to five CAs can be entered in the row to the right of each factor. Each row contains the CA scores for a single factor. For example, blanks 31-35 are used for CA scores with respect to the factor Fields of Fire.

Data restrictions. The following restrictions apply to the data:

1. The number of alternative courses of action in Node 0 must be at least 2 but not more than 5. The calculator will not accept a value greater than 5.
2. For each node of weights (Nodes 1-6), at least one weight must have a value of 100. More than one weight, or all weights, in each node can have values of 100 if you consider the factors equally important. If you fail to enter at least one weight of 100, the error message "EN" is displayed. (See page 34 for further explanation of error and warning messages.)

calculator work sheet(continued)

3. Within each node of CA scores (Nodes 7-31), at least one CA must have a score of 100 and at least one CA, a score of 0. The error message "EN" is displayed if you fail to enter a 100 and a 0. Exception: if a factor is equally advantageous for all CAs, each CA receives a score of 100, and the corresponding factor receives a weight of 0, because these scores have no impact on overall mission accomplishment. If you enter a score of 100 for each CA after setting the corresponding factor weight at a value other than 0, a "W2" warning message is displayed.

calculator work sheet (continued)

Number of Alternative Courses of Action: NODE 0 0. _____

Factor Category Weights

Factor Weights

Scores:

CA1

CA2

CA3

CA4

CA5

NODE 1

NODE 2

1 Terrain	6 Field of fire	NODE 7 →	31	32	33	34	35
	7 Cover & conceal	NODE 8 →	36	37	38	39	40
	8 Mobility	NODE 9 →	41	42	43	44	45
	9 S/D key terrain	NODE 10 →	46	47	48	49	50
	10 Observation	NODE 11 →	51	52	53	54	55
	11 Nat/art obstacle	NODE 12 →	56	57	58	59	60

NODE 3

2 U.S. Force	12 Disposition	NODE 13 →	61	62	63	64	65
	13 Strngth/cndition	NODE 14 →	66	67	68	69	70
	14 Reserves	NODE 15 →	71	72	73	74	75
	15 Logistic supprt	NODE 16 →	76	77	78	79	80
	16 Prob act/react	NODE 17 →	81	82	83	84	85
	17 Commnd & contrl	NODE 18 →	86	87	88	89	90

NODE 4

3 OPFOR	18 Disposition	NODE 19 →	91	92	93	94	95
	19 Strngth/cndition	NODE 20 →	96	97	98	99	100
	20 Reserves	NODE 21 →	101	102	103	104	105
	21 Logistic supprt	NODE 22 →	106	107	108	109	110
	22 Commnd & contrl	NODE 23 →	111	112	113	114	115

NODE 5

4 Weather	23 Observatn/vsibilty	NODE 24 →	116	117	118	119	120
	24 Cover & conceal	NODE 25 →	121	122	123	124	125
	25 Mobility	NODE 26 →	126	127	128	129	130
	26 Extreme weather	NODE 27 →	131	132	133	134	135

NODE 6

5 Risk	27 U.S. actn/reactn	NODE 28 →	136	137	138	139	140
	28 Depnd on oth cnds	NODE 29 →	141	142	143	144	145
	29 Depnd on supr/dcp	NODE 30 →	146	147	148	149	150
	30 Unexpctd weather	NODE 31 →	151	152	153	154	155

SOLUTIONS

Figure 11. Calculator work sheet.

LOADING THE ENCOA PROGRAM

Initially, the entire ENCOA program must be loaded into the calculator from magnetic data cards. A full 320-word memory is required to use the ENCOA program. While the HP41-CV has an internal memory capacity of that size, the HP41-C has an internal memory of only 64 words and the remainder must be provided through external modules. If your HP41-C has four external memory modules providing 64 words each (rather than one providing 256 words), the software loading procedure differs from that of the HP41-CV. However, both procedures are quite simple.

HP41-C, with four external memory modules. The ENCOA program for the HP41-C is stored on seven magnetic data cards. Each card has two tracks (top and bottom), thus the program is stored on a total of 14 tracks.

There are four subroutines which must be loaded. PR (Primary) is stored on three tracks. RV (Review) is stored on three tracks. SLV (Solve) is stored on five tracks. And, ED (Edit) is stored on three tracks.

The template should be removed to reveal the labels of keys used to load the program. The loading procedure is as follows:

1. Remove the fourth memory module and install the card reader in its place.
2. Press the ON key and the <-- key simultaneously to turn on the calculator. This erases current memory and displays a "MEMORY LOST" message.
3. Press "XEQ (ALPHA) SIZE (ALPHA) 064". When the ALPHA key is depressed, the calculator will accept the letters S, I, Z, E. A second depression cancels the alphabetic mode. This statement allocates memory space for the subroutines.
4. Press the USER key to activate the user programming function. The word "USER" should appear in the lower left sector of the display.
5. Load the data cards as follows:
 - a. Load the three tracks labeled PR. Gently insert the first card, PR1 on top, into the diagonal slot on the right side of the card reader. The card reader will automatically pull the card through to the other side. Successful storage of that information in memory is indicated by the readiness statement "RDY 02 of 03". (If an error message is displayed, clean the card with a damp cloth and reinsert it.) Invert the card so that PR2 is on top and insert it in the card reader. Again, a statement of readiness should appear. Follow the same steps to load PR3. When loading is complete, the calculator responds with a "WORKING" message.

loading the program (continued)

- b. Press "SHIFT GTO. . ". (The SHIFT key which is not labelled is the yellow key in the third row.) This statement ensures that the next subroutine will be loaded in memory in addition to the previous one rather than in place of it. The calculator should display a "PACKING" message.
- c. Load the three tracks labelled RV.
- d. Press "SHIFT GTO . ." and load the five tracks labelled SLV.
- e. Press "SHIFT GTO . . " and load the three tracks labelled ED.
6. Remove the card reader and reinsert the fourth memory module.
7. Press "XEQ (ALPHA) SIZE (ALPHA) 130" to allocate memory for the data. You are now ready to enter a data model via the ENTER mode.

HP41-CV. The ENCOA program for the HP41-CV is stored on a total of 21 tracks (11 cards). To load the program:

1. Turn the calculator ON by pressing the ON key.
2. Gently insert the first data card, track 1 on top, into the diagonal slot on the right side of the card reader attachment. The card reader will automatically pull the card through to the other side. Successful storage of that information in memory is indicated by a statement of readiness for the second track ("RDY 02 OF 21"). If an error message is displayed, continue to reinsert the card until the readiness statement is displayed. Sometimes dirt on the card causes this malfunction; wiping it with a damp cloth may help.
3. Invert the card so that track 2 is on top and insert it on the card reader. Again, a statement of readiness should be displayed when the information has been stored.
4. Follow the above procedure to load the remaining 19 tracks. Loading the tracks in the wrong order will not have a detrimental effect on the program provided all of the tracks are read.

ENTERING, EDITING, AND EVALUATING MODELS WITH THE CALCULATOR

The ENCOA program operates in eight general modes: ENTER, EDIT, SOLVE, MOST, LEAST, RE SOL, SAVE, and LOAD. While there is some latitude for variation, a typical operating procedure would use the following steps. (Operations designated by an asterisk are optional.)

1. Turn on the calculator.
2. If the USER function is not activated, press the USER key.
3. Press the ENTER key and enter all of the data for Nodes 1-31, or press the LOAD key and load a previous model from magnetic cards.
- *4. Press the EDIT key and modify the data or correct errors.
5. Press the SOLVE key to obtain a solution.
- *6. Press the LEAST or MOST key to obtain a rank-ordered list of the normalized factor weights.
- *7. Press the SAVE key, insert magnetic cards, and store the model.
8. Turn off the calculator.

Four of the operating modes will be described in this section. The first mode, ENTER, allows you to enter the work sheet data in a prompted, sequential manner. The second mode, EDIT, allows you to review the data which have been entered and make any necessary modifications. In the third mode, SOLVE, the calculator will perform the appropriate calculations and provide an overall weighted score for each CA in relation to mission accomplishment. In the fourth mode, RE SOL, you can review the overall solutions which have previously been calculated in the SOLVE mode.

The keys that are used to perform these functions are discussed below.

USER

To utilize the ENCOA program, the calculator must be in the user function. This is activated by pressing the USER key which is located directly below the display. Activation is confirmed by presentation of the word "USER" in the lower left sector of the display.

ENTER

To activate the data entry mode, press the ENTER key. (This is located at the top left of the keyboard and is designated as ENTER on the template.) A reference number will be displayed which corresponds to one of those on the work sheet. (For example, "0" refers to the number of alternative courses of action.) Enter the appropriate value and press the R/S key. The program will single-step you through all the entries, 0-155, displaying the next reference number following each entry. If fewer than five CAs have been specified, the program automatically omits those reference numbers.

Entry of data must be completed before editing is initiated. Transference out of this mode to perform another function and subsequent reentry at the point of departure is not possible.

function keys

R/S

When R/S is pressed, the characters which have been entered are processed by the calculator. This key must be pressed for any processing to occur. A second function of R/S is to display the next consecutive entry or solution.

<-(Delete)

The delete key, designated by "<-", allows you to erase, prior to pressing R/S, characters in the display that have been entered incorrectly. When the delete key is pressed, the right-most character is deleted.

EDIT

To review and edit the data, the EDIT key is used. When this key is pressed a "NODE?" statement is displayed. Enter the number of the node which you wish to review and press R/S to execute. The first reference number in that node will then appear, followed by a decimal point and its value (for example, 31.080 indicates that blank 31 has a value of 80). To change that value, merely enter the correct value followed by R/S. When you press the R/S key, the next consecutive entry in that node will appear. It is necessary to single step through every entry in a node when reassigning any value within that node, otherwise the new value will not be recorded.

Caution: If you reassign a factor weight of 100 within any of the Nodes 2-6, then a "W1" warning message is displayed. It indicates that you must reevaluate the original factor category weights (Node 1) to take this change in consideration. (See page 15 for details on factor category weighting.)

SOLVE

After the data have been entered and any necessary corrections have been made, the SOLVE key can be pressed to obtain a solution. The calculations take approximately three minutes to perform and completion is signified by a "RDY" statement. Press the R/S key to display the overall weighted score for the first CA. The display follows a similar format to that described above: the CA number followed by a decimal point and the value of the score. For example, 1.75 indicates CA1 has a score of 75. Each additional solution is displayed following a depression of the R/S key.

RE SOL

Once a model has been solved, you can use the RE SOL key to review the overall solutions without having to wait again for time-consuming calculations in the SOLVE mode. Pressing this key displays the overall weighted score for the first CA. An additional CA solution is displayed following each depression of the F/S key.

INTERPRETING YOUR WEIGHTS WITH THE CALCULATOR

Two modes are provided to facilitate comparison of the relative importance of factor weights. The factor weights are normalized and ranked (1-25) regardless of their categories. (See page 23 for details of the manual procedure and further discussion on the interpretation of weights.) The two modes, MOST and LEAST, can be used only immediately following calculation of the solution with the SOLVE key. This is the single point at which the normalized weights are in memory, and their availability is signified by the status flag "4" in the lower right sector of the display. These normalized weights are lost by any subsequent operations such as ENTER or EDIT. The MOST and LEAST modes are discussed below.

MOST

To obtain a ranking of all 25 factors in order of decreasing importance, the MOST important factors mode is used. When the MOST key is pressed, the number "1." appears initially, indicating that the factor which follows is the first in a rank ordered list. Press R/S to obtain this factor. The display uses the format of a factor reference number followed by a decimal point and its normalized weight in percent. (For example, 28.11 indicates that factor 28 has a normalized weight of 11 percent.) An additional depression of R/S displays the number "2." indicating that the factor which follows is the second most important of the 25 factors, and another depression of R/S displays the factor and its normalized weight. Continue to press R/S, first obtaining the rank of the next factor, then the factor and its weight.

LEAST

The LEAST important factors mode functions in an identical manner to the MOST mode except the factors are listed in order of increasing importance. A depression of the LEAST key displays the number "25." indicating that the factor which follows is the least important of the 25. Another depression of R/S displays the factor reference number followed by a decimal point and its normalized weight in percent. Additional depressions of R/S display the next ascending rank in the ordered list, then the associated factor and its normalized weight.

SAVING AND LOADING MODELS WITH THE CALCULATOR

Two additional modes in which the ENCOA program operates are SAVE model and LOAD model. (A model refers to the data comprising the Calculator Work Sheet.) These modes are discussed below.

Note: If you are using the HP41-C with four external memory modules, the SAVE and LOAD modes are not available for use because access to both the card reader and full memory (all four modules) is required simultaneously.

SAVE

The calculator will hold a given model in its memory when turned off but to make a permanent record of a model, magnetic data cards are used. Each data card has two tracks (top and bottom). When storing a model, four tracks (two cards) are needed.

To store a model, first press the SAVE key. Then gently insert a data card, track 1 on top, into the diagonal opening on the right side of the card reader attachment until the card is caught and automatically pulled through. Successful storage of data on this track is indicated by a statement of readiness for the second of four tracks. (If an error message is displayed, clean the card with a cloth and continue to reinsert it until the readiness statement is displayed.) Next, invert the card, track 2 on top, and insert it. The display should then indicate that it is ready to accept track 3. The above procedure is followed with the second card, storing data on tracks 3 and 4.

To avoid later confusion, it is suggested that the data cards be labeled with felt-tip pen. The cards are reusable, though. Should you wish to erase an existing model, simply record over it and remove the label with a damp cloth.

LOAD

To load a model stored on data cards into the calculator's memory, first press the LOAD key. Then gently insert the first of the two data cards, track 1 on top, into the card reader. A statement indicating readiness to accept the second of four tracks should then be displayed; otherwise, continue to reinsert the card until this statement is displayed. Next, invert the card, track 2 on top, and insert it in the card reader. Again, the ready statement should be displayed. Follow the same procedure for the second card, loading tracks 3 and 4.

Loading tracks in the wrong order will not have a detrimental effect provided all four tracks are read.

ERROR MESSAGES, WARNINGS, AND STATUS FLAGS

Error Messages

ER

Error Range. This message is displayed when a value that is out of range is entered; for example, a data value greater than 100 or a node number greater than 31. To correct the error, press R/S to return to the previous entry point and enter an acceptable value.

EN

Error Node. This message is displayed if you fail to meet two conditions:

1. When entering or editing weights (Nodes 1-6), at least one weight in each node must have a value of 100.
2. When entering or editing CA scores (Nodes 7-31), one CA within each node must have a score of 100 and one must have a score of 0.

To correct an ER or EN error, press R/S to return to the beginning of that node then enter acceptable values.

E92

An entry of 92 is not possible due to limitations of the calculator. An adjacent number (91 or 93) would be equally suitable. Press R/S to return to the previous entry point and enter an acceptable value.

Warning Messages

WI

This warning message is displayed when, in the EDIT mode, a factor weight in any of the Nodes 2-6 has been reassigned from some smaller value to 100 or from 100 to some smaller value.

To correct, press R/S and complete the review of each entry in that node, otherwise the new value will not be recorded. Next, in the EDIT mode enter Node 1 and reevaluate the factor category weights taking in account the new factor weighted 100. (See page 15 for details about factor category weighting.) Note: The calculator will not calculate a solution to the model in the SOLVE mode until you reenter Node 1 and review the factor category weights. If a solution is attempted, the calculator will display a "REV" (Review) statement. Press R/S to obtain the number of the node(s) that must be reviewed.

W2

This warning message indicates that you have assigned a score of 100 to each CA in that node and, at the same time, assigned a weight other than 0 to the corresponding factor. Any factor on which all CAs have been scored 100, indicating no difference in terms of mission accomplishment, must be assigned a weight of 0. (See page 11, procedure 2.)

To resolve the problem of inconsistent entries, if the calculator is currently in the ENTER node press R/S and complete data entry. Using the EDIT mode, reassign a weight of 0 to the factor in question.

Note: The calculator will not calculate a solution to the model in the SOLVE mode until the factor weight has been reviewed. Like the W1 message, if a solution is attempted before a correction is made, the calculator will display a "REV" statement and a depression of R/S will display the number of the node which must be reviewed. If multiple nodes need review, additional depressions of R/S will display the node numbers.

Status Flags

Status flags--the numbers 1, 2, or 4--are presented in the lower right sector of the display.

Flag 1 is a reminder that a W1 warning has occurred.

Flag 2 is a reminder that a W2 warning has occurred.

Flag 4 indicates that the normalized factor weights are in memory. In its presence, the MOST and LEAST nodes can be used.

APPENDIX A

ID#: 1.0 CATEGORY: TERRAIN FACTORS

FACTOR ID#	Name	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
		Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1.1	FIELDS OF FIRE	80	20	90	16	100	20	0	0				
1.2	COVER & CONCEALMENT	65	16	90	14	100	16	0	0				
1.3	MOBILITY	20	6	20	1	0	0	100	6				
1.4	SEIZE/DENY KEY TERRAIN	100	25	70	18	100	25	0	0				
1.5	OBSERVATION	90	22	80	18	100	22	0	0				
1.6	NATURAL/ARTIFICIAL OBSTACLES	50	12	100	12	70	8	0	0				
TOTAL		405	100		79		91		6				

Abbreviations

Rel - relative
Norm - normalized

Wtd - weighted
Wt - weight

Calculations

$$\text{Norm Wt} = \frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$$

$$\text{Wtd Score} = \frac{\text{Rel Score} \times \text{Norm Wt}}{100}$$

ID#: 2.0 CATEGORY: U.S. FORCE FACTORS

FACTOR		Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
ID#	Name	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
2.1	DISPOSITION	90	23	90	21	100	23	0	0				
2.2	STRENGTH & CONDITION	20	5	0	0	0	0	100	5				
2.3	RESERVES	100	26	70	18	100	26	0	0				
2.4	LOGISTIC SUPPORT	50	13	60	8	100	13	0	0				
2.5	PROBABLE ACTIONS/ REACTIONS	70	18	50	9	100	18	0	0				
2.6	COMMAND & CONTROL	60	15	60	9	100	15	0	0				
	TOTAL	390	100		65		95		5				

Abbreviations

Rel - relative
Norm - normalized

Wtd - weighted
Wt - weight

Calculations

$$\text{Norm Wt} = \frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$$

$$\text{Wtd Score} = \frac{\text{Rel Score} \times \text{Norm Wt}}{100}$$

ID#: 3.0 CATEGORY: OPPOSING FORCE FACTORS

ID#	FACTOR Name	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
		Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
3.1	CURRENT DISPOSITION	85	27	100	27	100	27	0	0				
3.2	STRENGTH & CONDITION	100	32	95	30	100	32	0	0				
3.3	RESERVES	45	14	100	14	100	14	0	0				
3.4	LOGISTIC SUPPORT	45	14	90	13	100	14	0	0				
3.5	COMMAND & CONTROL	45	14	100	14	100	14	0	0				
	TOTAL	320	100		98		100		0				

Abbreviations

Rel - relative
Norm - normalized

Wtd - weighted
Wt - weight

Calculations

Norm Wt = $\frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$

Wtd Score = $\frac{\text{Rel Score} \times \text{Norm Wt}}{100}$

ID#: 5.0

ID#	FACTOR	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
		Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
5.1	U.S. ACTIONS/REACTIONS	10	5	80	4	100	5	0	0				
5.2	DEPENDENCE ON OTHER COMMANDS	100	50	70	35	100	50	0	0				
5.3	DEPENDENCE ON SURPRISE/DECEPTION	50	25	90	22	100	25	0	0				
5.4	UNEXPECTED WEATHER	40	20	50	10	100	20	0	0				
	TOTAL	200	100		71		100		0				

Abbreviations

Rel - relative

Rel	- relative	Wtd	- weighted
Norm	- normalized	Wt	- weight

Calculations

$$\frac{\text{Factor Rel Wt}}{\text{Norm Wt}} = \frac{\text{Total Rel Wt}}{\text{Total Rel Wt}}$$
$$\text{Norm Wt} = \frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$$
$$\text{Wtd Score} = \frac{\text{Rel Score} \times \text{Norm Wt}}{100}$$

ID#: 0 CATEGORY: MISSION ACCOMPLISHMENT

FACTOR CATEGORY ID#	Name	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
		Rel	Norm	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd
1.0	TERRAIN	100	36	79	28	91	33	6	2				
2.0	U.S. FORCES	80	29	65	19	95	28	5	1				
3.0	OPPOSING FORCES	30	11	97	11	100	11	0	0				
4.0	WEATHER	5	2	79	2	50	1	50	1				
5.0	RISK	60	22	71	16	100	22	0	0				
TOTAL		275	100		76		95		4				

Abbreviations

Rel - relative
Norm - normalized
FCS - factor category score

Calculations

Wtd - weighted
Wt - weight
FCS - factor category score

$$\text{Norm Wt} = \frac{\text{Factor Category Rel Wt}}{\text{Total Rel Wt}} \times 100$$

$$\text{Wtd Score} = \frac{\text{FCS} \times \text{Norm Wt}}{100}$$

APPENDIX B

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1963

CA1: -----
 CA2: -----
 CA3: -----
 CA4: -----
 CA5: -----

0. MISSION ACCOMPLISHMENT

1. TERRAIN	R W (_ / _ _)	
1.1 Fields of fire	R W (_ / _ _)	0 20 40 60 80 100
1.2 Cover and concealment	R W (_ / _ _)	0 20 40 60 80 100
1.3 Mobility	R W (_ / _ _)	0 20 40 60 80 100
1.4 Seize/deny key terrain	R W (_ / _ _)	0 20 40 60 80 100
1.5 Observation	R W (_ / _ _)	0 20 40 60 80 100
1.6 Natural/artificial obstacles	R W (_ / _ _)	0 20 40 60 80 100

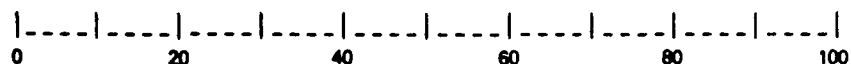
2. U.S. FORCE	R W (_ / _ _)	
2.1 Disposition	R W (_ / _ _)	0 20 40 60 80 100
2.2 Strength and condition	R W (_ / _ _)	0 20 40 60 80 100
2.3 Reserves	R W (_ / _ _)	0 20 40 60 80 100
2.4 Logistic support	R W (_ / _ _)	0 20 40 60 80 100
2.5 Probable actions/reactions	R W (_ / _ _)	0 20 40 60 80 100
2.6 Command and control	R W (_ / _ _)	0 20 40 60 80 100

3. OPFOR FACTORS

R W
(_ / _)

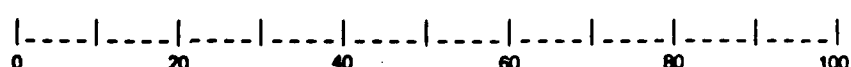
3.1 Disposition

R W
(_ / _)



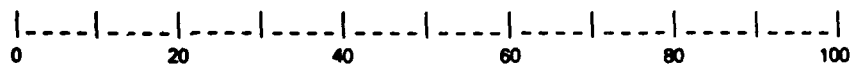
3.2 Strength and condition

R W
(_ / _)



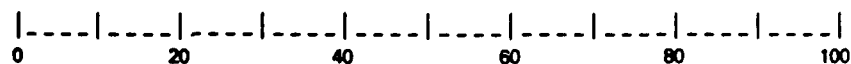
3.3 Reserves

R W
(_ / _)



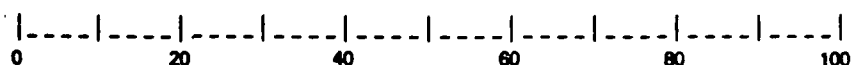
3.4 Logistic support

R W
(_ / _)



3.5 Command and control

R W
(_ / _)

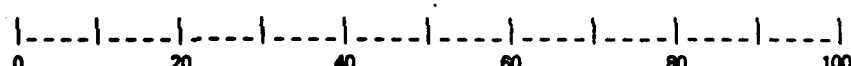


4. WEATHER

R W
(_ / _)

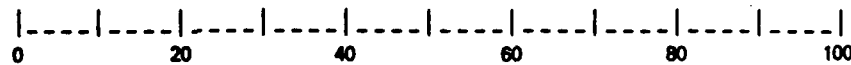
4.1 Observation/visibility

R W
(_ / _)



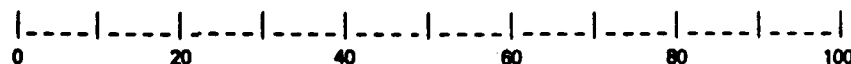
4.2 Cover/concealment

R W
(_ / _)



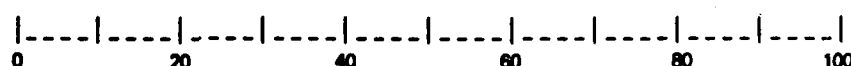
4.3 Mobility

R W
(_ / _)



4.4 Extreme weather effects

R W
(_ / _)

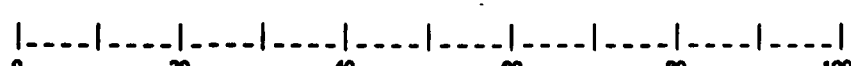


5. RISK

R W
(_ / _)

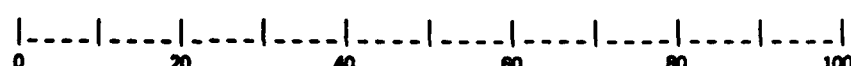
5.1 U.S. actions/reactions

R W
(_ / _)



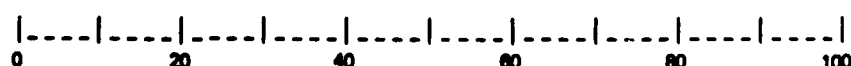
5.2 Dependence on other commands

R W
(_ / _)



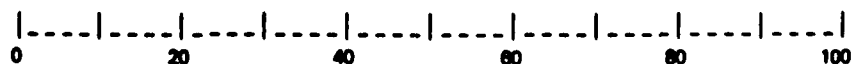
5.3 Dependence on surprise/deception

R W
(_ / _)



5.4 Unexpected weather

R W
(_ / _)



ID#: 1.0 CATEGORY: TERRAIN FACTORS

FACTOR	ID#	Name	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
			Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1.1 FIELDS OF FIRE														
1.2 COVER & CONCEALMENT														
1.3 MOBILITY														
1.4 SEIZE/DENY KEY TERRAIN														
1.5 OBSERVATION														
1.6 NATURAL/ARTIFICIAL OBSTACLES														
TOTAL														

Abbreviations

Rel - relative Wtd - weighted
 Norm - normalized Wt - weight

Calculations

Norm Wt = $\frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$

Wtd Score = $\frac{\text{Rel Score} \times \text{Norm Wt}}{100}$

ID#: 2.0 CATEGORY: U.S. FORCE FACTORS

FACTOR	ID#	Name	Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
			Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
2.1 DISPOSITION														
2.2 STRENGTH & CONDITION														
2.3 RESERVES														
2.4 LOGISTIC SUPPORT														
2.5 PROBABLE ACTIONS/ REACTIONS														
2.6 COMMAND & CONTROL														
TOTAL														

Abbreviations

Rel - relative Wtd - weighted
Norm - normalized Wt - weight

Calculations

Norm Wt = Factor Rel Wt x 100
Total Rel Wt

Wtd Score = Rel Score x Norm Wt
100

ID#: 3.0 CATEGORY: OPPOSING FORCE FACTORS

FACTOR		Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
ID#	Name	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
3.1	CURRENT DISPOSITION												
3.2	STRENGTH & CONDITION												
3.3	RESERVES												
3.4	LOGISTIC SUPPORT												
3.5	COMMAND & CONTROL												
	TOTAL												

Abbreviations

Rel - relative Wtd - weighted
 Norm - normalized Wt - weight

Calculations

Norm Wt = $\frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$

Wtd Score = $\frac{\text{Rel Score} \times \text{Norm Wt}}{100}$

ID#: 5.0.

[illegible]

Abbreviations

Rel	- relative	Wtd	- weighted
Norm	- normalized	Wt	- weight

Calculations

$$\text{Norm Wt} = \frac{\text{Factor Rel Wt}}{\text{Total Rel Wt}} \times 100$$
$$\text{Wtd Score} = \frac{\text{Rel Score} \times \text{Norm Wt}}{100}$$

ID#: 0 CATEGORY: MISSION ACCOMPLISHMENT

FACTOR CATEGORY		Weight		CA1 score		CA2 score		CA3 score		CA4 score		CA5 score	
ID#	Name	Rel	Norm	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd	FCS	Wtd
1.0	TERRAIN												
2.0	U.S. FORCES												
3.0	OPPOSING FORCES												
4.0	WEATHER												
5.0	RISK												
	TOTAL												

Abbreviations

Rel - relative Wtd - weighted
 Norm - normalized Wt - weight
 FCS - factor category score

Calculations

Norm Wt = $\frac{\text{Factor Category Rel Wt}}{\text{Total Rel Wt}} \times 100$ Wtd Score = $\frac{\text{FCS} \times \text{Norm Wt}}{100}$

Number of Alternative Courses of Action: NODE 0 0. _____

**Factor Category
Weights**

Factor Weights

Scores:

CA1

CA2

CA3

CA4

CA5

NODE 1

NODE 2

1 Terrain _____

6 Field of fire _____

7 Cover & conceal _____

8 Mobility _____

9 S/D key terrain _____

10 Observation _____

11 Nat/art obstacle _____

NODE 7 → 31 _____ 32 _____ 33 _____ 34 _____ 35 _____

NODE 8 → 36 _____ 37 _____ 38 _____ 39 _____ 40 _____

NODE 9 → 41 _____ 42 _____ 43 _____ 44 _____ 45 _____

NODE 10 → 46 _____ 47 _____ 48 _____ 49 _____ 50 _____

NODE 11 → 51 _____ 52 _____ 53 _____ 54 _____ 55 _____

NODE 12 → 56 _____ 57 _____ 58 _____ 59 _____ 60 _____

NODE 3

2 U.S. Force _____

12 Disposition _____

13 Strngth/cndition _____

14 Reserves _____

15 Logistic supprt _____

16 Prob act/react _____

17 Commnd & contrl. _____

NODE 13 → 61 _____ 62 _____ 63 _____ 64 _____ 65 _____

NODE 14 → 66 _____ 67 _____ 68 _____ 69 _____ 70 _____

NODE 15 → 71 _____ 72 _____ 73 _____ 74 _____ 75 _____

NODE 16 → 76 _____ 77 _____ 78 _____ 79 _____ 80 _____

NODE 17 → 81 _____ 82 _____ 83 _____ 84 _____ 85 _____

NODE 18 → 86 _____ 87 _____ 88 _____ 89 _____ 90 _____

NODE 4

3 OPFOR _____

18 Disposition _____

19 Strngth/cndition _____

20 Reserves _____

21 Logistic supprt _____

22 Commnd & contrl _____

NODE 19 → 91 _____ 92 _____ 93 _____ 94 _____ 95 _____

NODE 20 → 96 _____ 97 _____ 98 _____ 99 _____ 100 _____

NODE 21 → 101 _____ 102 _____ 103 _____ 104 _____ 105 _____

NODE 22 → 106 _____ 107 _____ 108 _____ 109 _____ 110 _____

NODE 23 → 111 _____ 112 _____ 113 _____ 114 _____ 115 _____

NODE 5

4 Weather _____

23 Observatn/vsibilty _____

24 Cover & conceal _____

25 Mobility _____

26 Extreme weather _____

NODE 24 → 116 _____ 117 _____ 118 _____ 119 _____ 120 _____

NODE 25 → 121 _____ 122 _____ 123 _____ 124 _____ 125 _____

NODE 26 → 126 _____ 127 _____ 128 _____ 129 _____ 130 _____

NODE 27 → 131 _____ 132 _____ 133 _____ 134 _____ 135 _____

NODE 6

5 Risk _____

27 U.S. actn/reactn _____

28 Depnd on oth cnds _____

29 Depnd on supr/dcp _____

30 Unexpctd weather _____

NODE 28 → 136 _____ 137 _____ 138 _____ 139 _____ 140 _____

NODE 29 → 141 _____ 142 _____ 143 _____ 144 _____ 145 _____

NODE 30 → 146 _____ 147 _____ 148 _____ 149 _____ 150 _____

NODE 31 → 151 _____ 152 _____ 153 _____ 154 _____ 155 _____

SOLUTIONS _____

Calculator work sheet

	Category weight	Normalized factor weights (within cat.)	Normalized factor weights (total)	Top 5 most important factors	Weights
1.0	TERRAIN				
1.1	Fields of fire			1	
1.2	Cover & conceal			2	
1.3	Mobility			3	
1.4	Seize/deny key terrain			4	
1.5	Observation			5	
1.6	Nat/art obstacles				
	Total Terrain	= 100			
2.0	U.S. FORCE			10 least important factors	
2.1	Disposition				
2.2	Strength/cond.				
2.3	Reserves			1	
2.4	Logistic support			2	
2.5	Prob. act/reacts.			3	
2.6	Command/control			4	
	Total U.S. Force	= 100		5	
				6	
3.0	OPFOR			7	
3.1	Current dispos.			8	
3.2	Strength/cond.			9	
3.3	Reserves			10	
3.4	Logistic support				
3.5	Command/control				
	Total OPFOR	= 100			
4.0	WEATHER				
4.1	Observ/visibility				
4.2	Cover & conceal				
4.3	Mobility				
4.4	Extreme weather eff.				
	Total Weather	= 100			
5.0	RISK				
5.1	U.S. act/reaction				
5.2	Dep. on other comm.				
5.3	Dep. on sur/decpt.				
5.4	Unexpected weather				
	Total Risk	= 100	100	= Total, all factors	

Summary of normalized weights calculation sheet

Number of Alternative Courses of Action: NODE 0 0. _____

Factor Category	Weights	Factor Weights	Scores:	CA1	CA2	CA3	CA4	CA5
NODE 1		NODE 2						
1 Terrain	_____	6 Field of fire	NODE 7 → 31. _____	32. _____	33. _____	34. _____	35. _____	
		7 Cover & conceal	NODE 8 → 36. _____	37. _____	38. _____	39. _____	40. _____	
		8 Mobility	NODE 9 → 41. _____	42. _____	43. _____	44. _____	45. _____	
		9 S/D key terrain	NODE 10 → 46. _____	47. _____	48. _____	49. _____	50. _____	
		10 Observation	NODE 11 → 51. _____	52. _____	53. _____	54. _____	55. _____	
		11 Nat/art obstacle	NODE 12 → 56. _____	57. _____	58. _____	59. _____	60. _____	
NODE 3								
2 U.S. Force	_____	12 Disposition	NODE 13 → 61. _____	62. _____	63. _____	64. _____	65. _____	
		13 Strngth/cndition	NODE 14 → 66. _____	67. _____	68. _____	69. _____	70. _____	
		14 Reserves	NODE 15 → 71. _____	72. _____	73. _____	74. _____	75. _____	
		15 Logistic supprt	NODE 16 → 76. _____	77. _____	78. _____	79. _____	80. _____	
		16 Prob act/react	NODE 17 → 81. _____	82. _____	83. _____	84. _____	85. _____	
		17 Commnd & contrl.	NODE 18 → 86. _____	87. _____	88. _____	89. _____	90. _____	
NODE 4								
3 OPFOR	_____	18 Disposition	NODE 19 → 91. _____	92. _____	93. _____	94. _____	95. _____	
		19 Strngth/cndition	NODE 20 → 96. _____	97. _____	98. _____	99. _____	100. _____	
		20 Reserves	NODE 21 → 101. _____	102. _____	103. _____	104. _____	105. _____	
		21 Logistic supprt	NODE 22 → 106. _____	107. _____	108. _____	109. _____	110. _____	
		22 Commnd & contrl	NODE 23 → 111. _____	112. _____	113. _____	114. _____	115. _____	
NODE 5								
4 Weather	_____	23 Observatn/vsibilty	NODE 24 → 116. _____	117. _____	118. _____	119. _____	120. _____	
		24 Cover & conceal	NODE 25 → 121. _____	122. _____	123. _____	124. _____	125. _____	
		25 Mobility	NODE 26 → 126. _____	127. _____	128. _____	129. _____	130. _____	
		26 Extreme weather	NODE 27 → 131. _____	132. _____	133. _____	134. _____	135. _____	
NODE 6								
5 Risk	_____	27 U.S. actn/reactn	NODE 28 → 136. _____	137. _____	138. _____	139. _____	140. _____	
		28 Depnd on oth cnds	NODE 29 → 141. _____	142. _____	143. _____	144. _____	145. _____	
		29 Depnd on supr/dcp	NODE 30 → 146. _____	147. _____	148. _____	149. _____	150. _____	
		30 Unexpctd weather	NODE 31 → 151. _____	152. _____	153. _____	154. _____	155. _____	

SOLUTIONS _____

Number of Alternative Courses of Action: NODE 0 0. _____

**Factor Category
Weights**

Factor Weights

Scores: CA1 CA2 CA3 CA4 CA5

NODE 1

NODE 2

1 Terrain _____	6 Field of fire _____	NODE 7 → 31 _____	32 _____	33 _____	34 _____	35 _____
	7 Cover & conceal _____	NODE 8 → 36 _____	37 _____	38 _____	39 _____	40 _____
	8 Mobility _____	NODE 9 → 41 _____	42 _____	43 _____	44 _____	45 _____
	9 S/D key terrain _____	NODE 10 → 46 _____	47 _____	48 _____	49 _____	50 _____
	10 Observation _____	NODE 11 → 51 _____	52 _____	53 _____	54 _____	55 _____
	11 Nat/art obstacle _____	NODE 12 → 56 _____	57 _____	58 _____	59 _____	60 _____

NODE 3

2 U.S. Force _____	12 Disposition _____	NODE 13 → 61 _____	62 _____	63 _____	64 _____	65 _____
	13 Strngth/cndition _____	NODE 14 → 66 _____	67 _____	68 _____	69 _____	70 _____
	14 Reserves _____	NODE 15 → 71 _____	72 _____	73 _____	74 _____	75 _____
	15 Logistic supprt _____	NODE 16 → 76 _____	77 _____	78 _____	79 _____	80 _____
	16 Prob act/react _____	NODE 17 → 81 _____	82 _____	83 _____	84 _____	85 _____
	17 Commnd & contrl _____	NODE 18 → 86 _____	87 _____	88 _____	89 _____	90 _____

NODE 4

3 OPFOR _____	18 Disposition _____	NODE 19 → 91 _____	92 _____	93 _____	94 _____	95 _____
	19 Strngth/cndition _____	NODE 20 → 96 _____	97 _____	98 _____	99 _____	100 _____
	20 Reserves _____	NODE 21 → 101 _____	102 _____	103 _____	104 _____	105 _____
	21 Logistic supprt _____	NODE 22 → 106 _____	107 _____	108 _____	109 _____	110 _____
	22 Commnd & contrl _____	NODE 23 → 111 _____	112 _____	113 _____	114 _____	115 _____

NODE 5

4 Weather _____	23 Observatn/vsibilty _____	NODE 24 → 116 _____	117 _____	118 _____	119 _____	120 _____
	24 Cover & conceal _____	NODE 25 → 121 _____	122 _____	123 _____	124 _____	125 _____
	25 Mobility _____	NODE 26 → 126 _____	127 _____	128 _____	129 _____	130 _____
	26 Extreme weather _____	NODE 27 → 131 _____	132 _____	133 _____	134 _____	135 _____

NODE 6

5 Risk _____	27 U.S. actn/reactn _____	NODE 28 → 136 _____	137 _____	138 _____	139 _____	140 _____
	28 Depnd on oth ends _____	NODE 29 → 141 _____	142 _____	143 _____	144 _____	145 _____
	29 Depnd on supr/dcp _____	NODE 30 → 146 _____	147 _____	148 _____	149 _____	150 _____
	30 Unexptcd weather _____	NODE 31 → 151 _____	152 _____	153 _____	154 _____	155 _____

SOLUTIONS _____